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(54)【発明の名称】　コード化されたタイヤ識別及び無線周波数送信を採用し且つタイヤ交替又は交換時の再校正を可能にした遠隔タイヤ圧力監視システム

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(57)【特許請求の範囲】

【請求項１】それぞれ少なくとも１本のタイヤが取り付けられた車輪を複数個有する自動車において、タイヤ圧力監視システムが異常なタイヤ圧力を指示するための表示インタフェースを前記自動車の内側に備えること、さらに、該システムが、前記タイヤ毎に、以下の各手段を備える検知／送信手段を備えていること、

すなわち、該検知／送信手段は、

圧力を検知する手段と、

前記タイヤのそれぞれの温度補償圧力を示す信号を生成する手段と、

前記信号を符号化して符号化信号を生成すると共に前記タイヤのそれぞれと前記自動車上の位置を独自に識別する手段と、

前記符号化信号を送信する手段と、を備えていること、

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更に、前記システムが、

前記符号化信号を受信する手段と、

前記符号化信号を復号してそれに応じた表示信号を生成する手段と、

前記表示信号に従って、前記タイヤのそれぞれの低圧力と位置とを示す表示を提供する手段と、を備えていること、

から成る前記タイヤ圧力監視システムにおいて、

前記検知／送信手段が前記タイヤの内部に取り付けられていること、

前記システムが、前記自動車のタイヤを交替する場合に、前記タイヤのそれぞれの位置に関する情報を前記システムが再獲得するように前記システムを再校正する手段を備えていること、

前記システムを再校正する手段が、

前記マイクロコントローラと、前記表示を提供する手段に連係した押しボタンと、を備えており、この場合、前期押しボタンを所定のやり方で押すことにより前記自動車の前記タイヤの位置を格納するように前記マイクロコントローラをプログラムすること、
かつ、前記タイヤの各々に対して、前記システムを再校正する手段が、前記検知／送信手段の近くに取り付けられた磁気作動スイッチを有し、該磁気作動スイッチはその近傍の磁界の存在に応じて作動させられ、しかもこの場合、前記押しボタンを前記所定のやり方で押すことに関連して前記スイッチが作動し、これにより、前記自動車の前記タイヤの位置を格納するように前記マイクロコントローラをプログラムすること、
を特徴とする前記システム。
【請求項２】前記表示を提供する手段が、ドライバ情報コンソールと、前記押しボタンとから成り、
前記ドライバ情報コンソールが、前記自動車の動作に関する別の情報も提供する、
ことを特徴とする請求の範囲第２項記載のシステム。
【請求項３】前記符号化する手段が、特定用途向け集積回路（ASIC）から成り、
前記符号化信号が、多重ビットの識別コードを含む、ことを特徴とする請求の範囲第１項記載のシステム。
【請求項４】前記多重ビット識別コードが12ビットコードである、
ことを特徴とする請求の範囲第５項記載のシステム。
【請求項５】前記多重ビット識別コードが20ビットコードである、
ことを特徴とする請求の範囲第５項記載のシステム。
【請求項６】前記多重ビット識別コードが24ビットコードである、
ことを特徴とする請求の範囲第５項記載のシステム。
【請求項７】前記符号化する手段が、特定用途向け集積回路（ASIC）から成り、
前記符号化信号が、タイヤ圧力の状態を示す１ビットの圧力コードを含む、
ことを特徴とする請求の範囲第１項記載のシステム。
【請求項８】前記符号化する手段が、特定用途向け集積回路（ASIC）から成り、
前記タイヤのそれぞれの位置に関する情報をシステムに再獲得させ得るように、前記検知／送信手段が前記再校正する手段を教授する情報を提供しているかどうか、を示す１ビットの学習コードを前記符号化信号が含む、ことを特徴とする請求の範囲第１項記載のシステム。
【請求項９】前記符号化する手段が、特定用途向け集積回路（ASIC）から成り、
前記特定用途向け集積回路（ASIC）が、出力された符号化信号の間にドエル時間を設ける手段、を有し、前記符号化信号が、多重ビットの識別コードを含み、前記ドエル時間が、前記多重ビットの識別コードに基づいて決定

される、
ことを特徴とする請求の範囲第１項記載のシステム。
【請求項１０】前記多重ビット識別コードが、12ビットコードである、
ことを特徴とする請求の範囲第11項記載のシステム。
【請求項１１】前記多重ビット識別コードが、20ビットコードである、
ことを特徴とする請求の範囲第11項記載のシステム。
【請求項１２】前記多重ビット識別コードが、24ビットコードである、
ことを特徴とする請求の範囲第11項記載のシステム。
【請求項１３】前記圧力を検知する手段が、
隔壁により閉鎖されて室を画定する開放端部を持つハウジングを有する交換器であって、前記室が乾燥窒素で充填され、前記乾燥窒素に対向しない隔壁の側が前記タイヤの内部に露出された、変換器と、
第一及び第二の接点を有する通常は閉じたスイッチであって、前記第二の接点が前記隔壁と連係し、前記タイヤのうちの一つの圧力が所定値以下に下がると、前記隔壁が、前記通常は閉じたスイッチを開放するように、前記第一の接点から離れる方向に移動する、スイッチと、を備えたことを特徴とする請求の範囲第１項記載のシステム。
【請求項１４】前記信号を生成する手段が、表面弾性波（SAW）装置から成る、ことを特徴とする請求の範囲第１項記載のシステム。
【請求項１５】前記符号化信号を受信する手段が、再生受信機と表面弾性波（SAW）周波数制御装置とから成る、
ことを特徴とする請求の範囲第３項記載のシステム。
【請求項１６】前記符号化信号を復号する手段が、マイクロコントローラから成る、
ことを特徴とする請求の範囲第１項記載のシステム。
【請求項１７】更に、前記検知／送信手段のそれぞれに電力を供給するための複数のバッテリ手段、を備えたことを特徴とする請求の範囲第１項記載のシステム。
【発明の詳細な説明】
発明の背景
本発明は、自動車のタイヤ圧力を監視するためのシステムに関する。特に、本発明は、各車輪にバッテリ作動圧力センサを個別に設けることにより、独自にコード化した情報を自動車に取り付けた受信機に送信してドライバに表示する、タイヤ圧力監視システムに関する。
タイヤ圧力を指示する方法は、従来技術で種々知られている。これらの方法は、温度補償されたタイヤ圧力の情報を提供するタイヤ圧力センサを用いている。
温度変化に対する補償は、重要である。即ち、空気は温度と共に膨張し、自動車が長く作動するにつれてタイヤは熱くなるので、温度補償ができなかった場合は、圧力の示度が極端に高くなる。同様に、特に寒い気候のと

きは、タイヤ圧力の示度が低くなる。これらの実際よりも高い或いは低い示度は、一定温度に標準化する必要がある。

殆どの場合、従来の温度補償方法は、タイヤ圧力センサ出力の電子変動を利用していた。その例は、米国特許第4567459号、第4703650号、及び第4966034号に開示されている。

従来技術は、更に、自動社内のドライバにタイヤ圧力情報を連絡するための、種々の公知の方法を有している。これらの方法としては、同調回路及び無線送信機がある。前者の例は、上述した米国特許に開示されている。無線送信機を用いた方法の例は、米国特許4510484号、第4554527号、及び第5061917号に開示されている。

公知のタイヤ圧力監視システムは、自動車の各タイヤに係るディジタル値をコード化したものもある。かかる方法の例は、米国特許第5001457号及び上述した米国特許第5061917号に開示されている。

集積回路技術及び電力生成技術は、長寿命バッテリにより小型の集積回路に供電し得るまでに進歩した。自動車の車輪にバッテリ作動送信機を取り付けたシステムの例は、米国特許第4978941号に開示されている。従来の遠隔タイヤ圧力監視システムは、幾つかの欠点を有する。第一に、これらのシステムの中には例えば計器盤に正しい表示を行うために自動車組み立て時に一応校正されているものもあるが、これらのシステムでは、自動車のタイヤ交替等の標準的な整備を受ける際にシステムを再校正しなければならないことに起因する問題が考慮されていない。また、損傷した送信機の交換の問題、及び交換に伴う校正の問題も考慮されているとは思われない。更に、このようなシステムの組み立てコストが低下するにつれて、システムが普及することになる。その結果、異なるシステム間でコードが重複した場合、一方の自動車のタイヤから圧力示度が、近くにいる別の自動車の受信機により誤って受信されて、別の自動車のコンソール上に報告されることになる。

また、従来、他の無線周波数源からの干渉を避けるために、適当な送信周波数の選定に意が払われてきたが、益々広範に実施されてきたキーレスエントリシステム等の遠隔制御装置には特有の問題が生じている。

従来のシステムで考慮されていないように思われる別の問題は、設置前の送信機のバッテリ消耗、及び低圧力示度の無い動作時における過渡のバッテリ消耗の回避に関わるものである。

タイヤを交替或いは交換した場合に、その自動車上のタイヤ位置を簡単に学習或いは再学習できる、タイヤ圧力監視システムを提供することが望まれる。また、他の自動車上の同様のシステムにより、或いはキーレスエントリシステム等の自動車内の他の無線周波数生成システムにより影響されない、システムを提供することが望まれる。更に、より新しい長寿命電源を利用すると共に、

電力を保存すべく通常動作では電力に頼らない温度補償圧力センサ技術を利用した、タイヤ圧力監視システムを提供することが望まれる。

発明の概要

上述したことに鑑みて、本発明の目的は、受信機と連係する送信機に固有のコードを採用した、遠隔タイヤ圧力監視システムを提供することである。

本発明の別の目的は、当該特定自動車と関係しているか否かを問わず付近の無線信号生成源からの干渉を回避した、遠隔タイヤ圧力監視システムを提供することである。

本発明の更に別の目的は、タイヤの交替後に受信機の再校正を可能とする、遠隔タイヤ圧力監視システムを提供することである。

本発明の更に別の目的は、バッテリの消耗を最小限にする、遠隔タイヤ圧力監視システムを提供することである。

これらの目的及びその他の目的に従って、本発明のシステムは、自動車内で使用される各送信機に対して独自の２進コードを採用している。このコードは、自動車上（例えば、キーレスエントリシステム又は自動車警告作動システム）か付近（例えば隣の自動車上の別の遠隔タイヤ圧力監視システム）の他のRF（無線周波数）生成システムにより影響されない周波数で、表面弾性波（SAW）に基づいた装置を用いて、振幅変調RF搬送波信号に重ね合わせることにより、送信される。タイヤの交替後、交換された車輪（従って交換された送信機）の位置に応じて自動車の受信機を再校正するためには、ドライバ情報コンソール上のボタンを押せばよい。

また、本発明のシステムは、通常の作動では電力を消費しない機械的な温度補償圧力センサを採用している。圧力が所定値以下に下がるとスイッチ接点が開き、信号がドライバ情報コンソールに送出される。

図面の簡単な説明

以下、添付図面に示した好適な実施例を介して、本発明の前記及びその他の目的及び特徴を詳細に説明する。

図１は、本発明の好適な実施例に係る受信及び送信装置のブロック図である。

図２は、送信装置の物理的構成を示す図である。

図３は、車輪のドロップセンタにおける送信装置の物理的配置を示す図である。

図４は、好適な実施例で採用された圧力スイッチを示す図である。

図５は、送信装置から受信装置への個々のデータバケットの送信タイミングを示すタイムチャートである。

図６は、従来の受信機の性能と比較して、本発明の表面弾性波（SAW）に基づいた受信機の性能を示す比較図である。

図７は、ドライバ情報コンソール（DIC）表示器の配置例である。

図８は、各車輪のタイヤ圧力情報が競合無くどのように受信機に送信されるかを示すタイミング図である。

好適な実施例の詳細な説明

図１は、本発明のタイヤ圧力遠隔監視システムのブロック図であり、ここでは、自動車の各タイヤ毎に設けられたシステムセンサ／送信機100がシステム受信機200と共に示されている。各センサ／送信機は、従来のねじ式タイヤ弁の背部に取り付けられて、図２に示すように組立体20の全体を構成する。後述するように、弁は、符号化されたタイヤ識別・圧力情報を受信機200に送信するためのアンテナとして機能する。

電子回路の詳細な説明に移る前に、装置の機械的側面の説明を若干行う。センサ／送信機の電子回路は、ガラスを充填したナイロンハウジング内に収容され、機械的振動、汚損等から更に保護するために絶縁材と共に嵌め込まれている。係る構成により、設置し易く製造コストの低いタイヤ内ユニットが得られる。装置の全重量は、当該装置を取り付ける車輪内に平衡錘を付ける必要をなくすために、できるだけ小さくする。また、装置の寸法をできるだけ小さくすることにより、装置を車輪のドロップセンタ空洞内に容易に取り付けることができ、タイヤ取り外し装置から保護するようにしている。図３は、このように車輪30のドロップセンタに組立体20を取り付けた一例を示す。

各センサ／送信機は、10年間電力を供給し続けることができるリチウム電源を内蔵している。電源の寿命が長いので恒久的に取り付けることが可能となり、電源を消耗して交替することがない。

電子回路は、表面取り付け部品を使用することにより、スペースを維持するように設計されている。電子回路用のプリント基板（PCB）は、好適な実施例では耐炎性繊維ガラスFR－４材料から形成するが、必要に応じて他の材料を使用してもよい。基板外素子は、歪解放貫通孔接続を用いて、主PCBに接続される。

図４に概略を示したセンサ400自体は、スイッチの開口部を介して低圧報告を発する機械的装置である。以下のことから分かるように、センサは電力を消費しないが、これは、装置の長寿命化に重要な特徴である。図４において、センサ400は、ベリリウム―銅合金から成る圧力隔膜410を有する。本体420は、黄銅から形成されている。ガラス／金属間シール430は支柱440を取り囲み、隔膜410と本体420とにより形成された室450を封止する。室450には、空気と同じ温度膨張特性を有する乾燥窒素が、低タイヤ圧力報告を生じさせるに必要な圧力を僅かに下回る圧力まで、充填されている。例えば、この圧力は、自動車のタイヤの場合、摂氏20度で25psi（1.76kg/cm²）、トランクに搭載した予備タイヤの場合は、60psi（4.22kg/cm²）とする。圧力は、トラックその他の種類のタイヤの場合、異なってもよい。従って、隔膜410の違い方の側は窒素に晒され、近い方の側はタイヤ内の空気に晒される。

支柱440は、隔膜と通常は接触している金の接点445を有する。タイヤ内の空気圧が所定値以下に減ると、室450内の窒素は、隔膜を接点445から離れる方向に付勢してスイッチを開く。このスイッチは、不活性素子であるので、上述したように電力を消費しない。

システムは、自動車に取り付けられたタイヤの圧力が所定値以下に降下すると、警告を発する。更に、システムは、自己監視しており、システムの誤動作を使用者に報告する。更にまた、受信機のデータ出力は、自動車内のドライバ情報コンソール用コンピュータと適合するように行うことができるので、タイヤ圧力情報を、他の操作情報と共に、計器盤に直接表示することができる。加えて、以下に説明するように、ドライバ情報コンソール用コンピュータの制御は、タイヤ交替の場合にシステムを再校正するために利用することができる。

再び図１を参照すると、非面弾性波（SAW）装置110は、各センサ／送信機100内の一次オシレータとして機能し、振幅変調RF（無線周波数）搬送波信号を発する。特定用途向け集積回路（ASIC）130は、装置の符号化回路の出力データ速度を設定するように構成されている（後述）。

表面弾性波装置110は、本来的に安定した周波数源であり、且つ広範な温度範囲に亘り周波数補償されるため、採用された。この補償特性は、タイヤが極めて冷たいか或いは熱いかに拘らず、装置が正確な無線送信周波数を付与する必要があるとき、特に重要である。表面弾性波装置110は、他の周波数源に対する干渉が最小となるように選定された低出力RF信号を発信する。またこの選定は、自動車の小径端部特性を介して安定した通信経路を構成する必要にも基づいている。従って、好適な実施例では、約418.0MHzの周波数が選定された。

特定用途向け集積回路130は、図４の圧力スイッチの開放に応じて、送信すべきデータを直列データ信号として生成する。図５に示すように、直列データ信号は、多重ビットの送信機識別（ID）コードと、１ビットの圧力コードと、１ビットの学習コードとを含む。送信機識別コードのビット数は、各送信機を正確に識別するために必要な独自のコードの数に応じて決まる。一実施例において、識別コードの長さは、12ビットであるが、必要に応じて、20ビット或いは24ビットとしてもよい。開始ビットは、各送信機識別コードに先行する。特定用途向け集積回路130は、発振器120を駆動するのに必要なTTL（トランジスタトランジスタ論理回路）レベル信号を生成する。特定用途向け集積回路130の入力部には、磁気的に作動する学習モードスイッチ160と、上述した圧力スイッチ170と、製造時に各送信機にプログラムされる個々の送信機コードを設定するのに必要な多重プリント基板トレーススイッチと、が含まれる。送信機自体は、FCC（米国通信委員会）の要求事項に従って設計されて

いる。

特定用途向け集積回路130にプログラムされるコードの別の特徴は、送信タイミングに関連したものである。図８のタイミング図に示したように、連続したデータバケット間にドエル期間即ちオフ期間が任意に設けられている。このオフ期間は、製造時に各送信機100にプログラムされた特定の送信機コードに指標付けされている。その結果、二つの送信機が全く同時に送信することはなく、送信機どうしの干渉又は無線周波数の衝突を起こり難くしている。この特徴は、本システムが例えば一定の自動車群全体で実現される場合に、特に重要である。かくして、当該自動車群内のある自動車の送信機が別の自動車に誤った低圧報告を発信する可能性は低下する。

12ビットコードの特徴は、また、各システムの受信機が当該システムの送信機から送られた信号と他の自動車に取り付けられた送信機からの信号とを識別する、ことを可能にする。

RF（無線周波数）信号出力は、それに重ね合わされた特定用途向け集積回路供給コードと共に、後段の増幅器140で増幅されて緩衝記憶される。増幅器140は、自動車の乗客室内で作動する受信機に効果的な通信を供するのに適した振幅を有するRF信号を生成することができる、単純で効率の良い低コスト共通エミッタ増幅器である。送信機の符号器特定用途向け集積回路からのデータ信号は、この増幅器段をオンオフする。その結果、振幅変調RF搬送波に重ね合わされた、ディジタル情報を伝送するパルス幅変調信号が得られる。

増幅器140の出力は、タイヤの弁棒150上に正確に整合する。この弁棒150は、車輪から露出して理想的な無線信号送信アンテナを形成するので、特に適したアンテナである。アンテナ整合回路180は、最大RF電力移動量に配慮している。タイヤ内に完全に収容れるアンテナを使用した場合、受信機のエネルギ量が減少し、一層強力な送信機か一層感度の高い受信機が必要となる。弁棒の長さは、送信機の動作周波数を考慮して、短くしている。従って、全ての無線周波数がアンテナに案内されるように、適切なインピーダンス整合回路180を設ける。また、弁棒を水汚損から隔絶し或いは装着される導電性車輪から絶縁するために、弁の外側に特殊な非導電性コーティングを施している。

次に図１の受信機200を参照すると、この受信機の機能は、装置内の各車輪から（即ち各送信機100から）情報を受領して当該情報を復号し、更にドライバ情報コンソールに送って自動車運転者に表示することである。各受信機200は、対応する送信機100の周波数で作動する超低電力再生型受信機である。受信機200は、同一自動車内で作動している他の無線周波数受信機と互換性があるように設計されている。このような受信機としては、例えば自動車に搭載したキーレスエントリシステム（キーを用いることなくドアロックを開閉する装置）に係る受信機がある。

受信機200は、低コストで効率が良く且つ高感度を呈する、再生設計を採り入れている。送信機100のように、受信機200は、表面弾性波に基づいた周波数制御装置を使用しており、温度及び機械的振動の両方を考慮して、動作周波数を効果的に安定させている。また、表面弾性波（SAW）に基づいた設計は、所望の動作周波数の周りで再生受信機により本来的に生成される、特徴的なスペクトルノイズの閉じ込めを確実に行い得るので有利である。この結果を、図６のグラフに示す。

動作周波数周辺の確実な閉じ込めは、自動車内の他の受信機に対する当該受信機の互換性を高める。この表面弾性波（SAW）に基づいた受信機の設計方法はまた、良好な選択性も呈する。

図１に示したように、アンテナ210は、弁棒アンテナ150から信号を受信する。受信機200の閉鎖容器内に取り付けられるアンテナ210は、システム送信機と受信機との間の偏波不整合の影響を減少させるために垂直及び水平の両偏波モードの感度が高い。

受信信号は、上述したように表面弾性波（SAW）周波数制御装置と共働して作動する、再生受信機220に送出される。データ調整部240は、外部ノイズにより生じることがある信号劣化を減少させるために、受信機220の出力側に設けられている。データ調整部240の出力は、マイクロコントローラ250に供給される。好適な実施例では、このマイクロコントローラは、８ビットであるが、プロセッサをより強力且つ低コストにするため、他の一層強力なマイクロコントローラの使用を考えてもよい。

マイクロコントローラ250は、水晶体260からタイミング信号を受信して信号内の情報を復号し、更にそれをバスインタフェース270に送る。バスインタフェース270は、復号された情報を、自動車内の特定のドライバ情報コンソールに応じて解釈する。自動車の製造業者が違えばコンソールの設計もそれぞれ異なることがあるように、バスインタフェースも各製造業者に独自のものとなる。インタフェースは、別個に入手可能な部品であるので、ここで詳述する必要はない。しかしながら、インタフェースは、通常、１個の集積回路と、おそらく４個又は５個の低コスト外部受動素子から成る。

自動車製造業者から供給されるとき、図７に一例を示したドライバ情報コンソール700自体は、複数のランプ即ち発光ダイオード（LED）から構成されている場合もあるし、液晶表示装置（LCD）から構成されている場合もある。

また、受信機200は、マイクロコントローラ250に係る車輪交替再校正スイッチインタフェースを有する。既に述べたように、システムの再校正は、タイヤの交替に起因する新しい車輪位置をシステムに「教授」するために必要である。実際上、製造時に初期の車輪位置（例え

ば、４輪自動車の場合、左側の前部及び後部、右側の前部及び後部の車輪位置）をシステムに「教授」するために、同様の構造を使用してもよい。

図１の受信機200の上側左隅には、電力調整回路280が示されている。この回路は、自動車の電気系統により印加される標準電圧（例えば、13.8V）を、無線周波数マイクロコントローラ回路及びドライバ情報コンソールインタフェース回路により使用される安定した5.0Vまで減少して調節する、電圧調整器を構成する。本発明の別の特徴に従って、各システム受信機は、それぞれの送信機に関係したコードを「学習」することができる。この特徴は、先に説明した無線周波数の衝突防止機能に更に寄与する。また、各受信機は、製造時に必要なコードを「教授」される。図７を参照すると、ドライバ情報コンソール700は、タイヤ圧力警告表示ランプ730乃至760の近傍に位置する、二つの超小型ボタン710及び720を有する。好適な実施例においては、システムを約60秒間「学習」モードにするために、二つのボタンを３秒間同時に押す。この間、受信機は、そのタイヤに取り付けられた送信機の一つからの特徴的な学習モード信号の受信に対して感心する。学習モード信号を送るために、各送信機近傍の各自動車タイヤの外側で、強い磁石を掃引する。各送信機は、その結果生じる磁気信号を受領すると、その学習信号を、新しい送信機コード群を学習するように統合されたシステム受信機に戻す。

各送信機が受信機を教授する順次（即ち、磁石が各車輪を通過する順次）は、自動車上の各ワイヤの現在位置、例えば左側前輪、左側後輪、右側前輪、右側後輪等を決定する。このプロセスにより、自動車の組み立て工場でシステムを設置する場合の開始位置校正が容易になる。

各送信機を磁石で掃引することのもう一つの機能は、製造時のスリープモードから各送信機を「覚醒」させることにより、設置に先立つ著しいバッテリの消耗を減少させて、送信機の貯蔵寿命を延ばすことである。

受信機は、また、送信機が損傷した場合に送信機の交替を実施するために、共通交替コード等の別の送信機コードに感応するように形成してもよい。

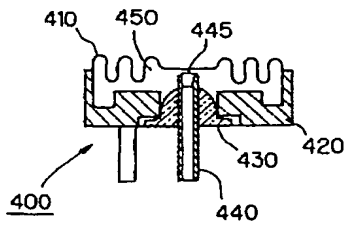
「学習」機能は、例えば、製造時のみならず、自動車＊の日常的な整備、例えばタイヤの交替時にも重要である。受信機200は、タイヤの交替時にその各送信機のコードを自動車上の各送信機の位置（例えば、左側前輪、左側後輪、右側前輪、右側後輪）に対応付けてプログラムされているので、各位置の再学習が必要となる。この再学習を行わないと、特定のタイヤのタイヤ圧力が過渡に減少した場合に、ドライバ情報コンソール上の表示が、間違った情報を与えることになる。

図７に示すように、二つの超小型ボタン710及び720は、それぞれ「従前」及び「現在」とラベル付けされている。タイヤ交替直後に、整備技術者は、ドライバ情報コンソール700上に所望のタイヤ位置が点灯するまで反復して「従前」ボタン710を押す。このようにして従前の位置を割り出した後、技術者は、タイヤの現在位置がコンソール700上に点灯するまで、「現在」ボタン720を押す。「現在」ボタンを開放すると、任意のあるタイヤの従前及び現在の位置が連続的に点滅しした後、休止（例えば、0.5秒）が続き、格納すべき再校正を表示する。この情報は、液晶表示装置（LCD）上に表示することもできる。この新しいタイヤ位置は、従前及び現在ボタンを３秒以内の短時間同時に押すことにより、システム受信機内に再校正される。この手順は、システムの各タイヤ毎に反復され、従前及び現在のボタンを同時に例えば10秒間押して最後のタイヤを再校正すると、終了する。

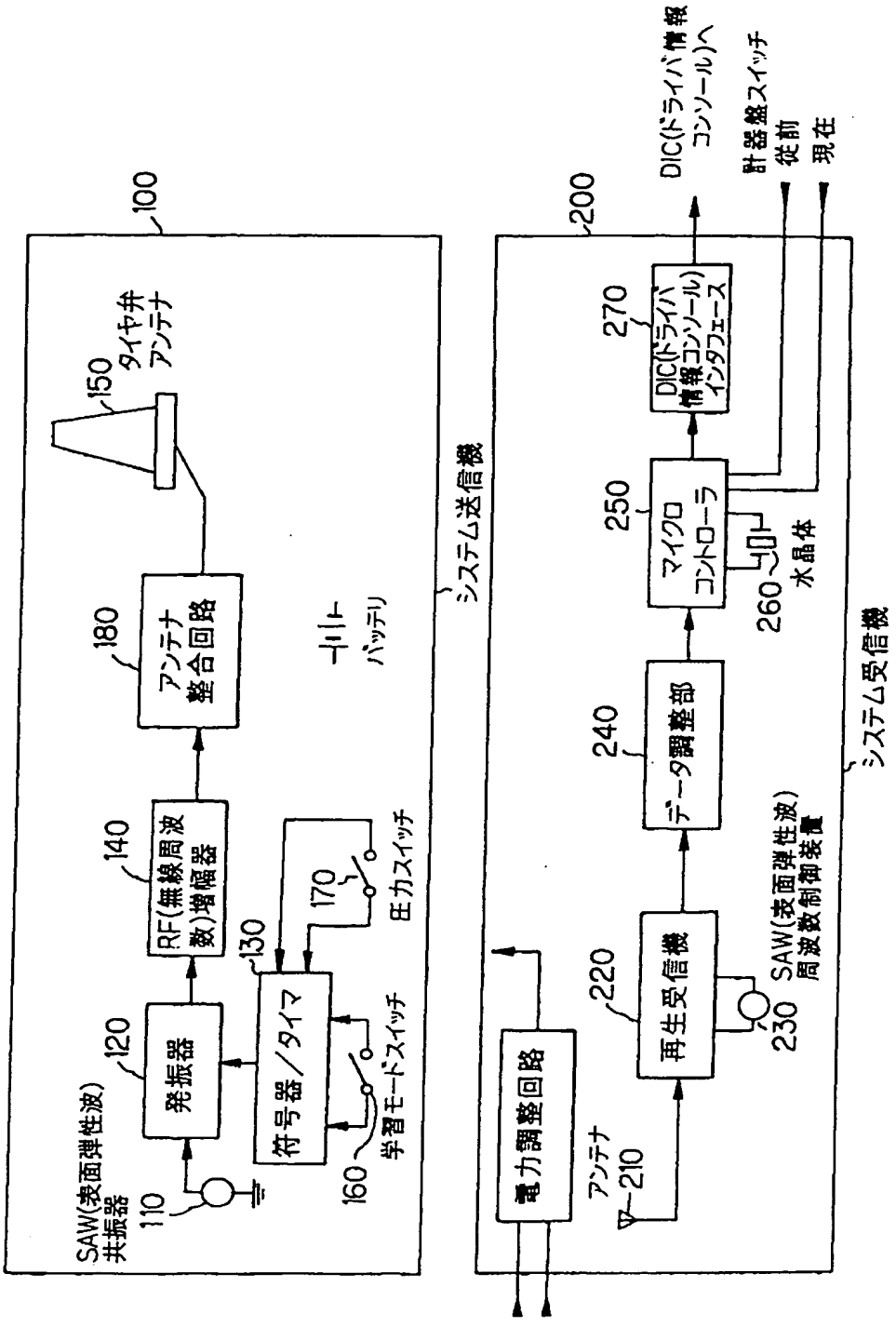
一例として、標準的なタイヤ交替において、前輪タイヤを後輪タイヤに、後輪タイヤを前輪タイヤに移し代える。第一の再校正ステップでは、ドライバ情報コンソール700上の左側前輪ランプが点灯するまで、「従前」ボタン710を押す。次に、コンソール700上の左側後輪ランプが点灯するまで「現在」ボタン720を押す。更に、従前と現在の両方のボタンを押すと、左側前輪から左側後輪に移動した送信機の位置が、受信機200内に格納される。

以上、本発明を好適な実施例に基づいて詳細に説明してきたが、本発明の範囲及び精神から逸脱することなく、種々の変更及び修正をなし得ることは、当業者には明らかである。従って、本発明は、添付請求の範囲によってのみ限定されると解されるべきである。

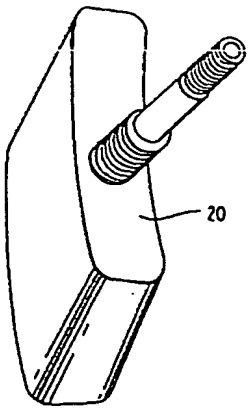
【第４図】



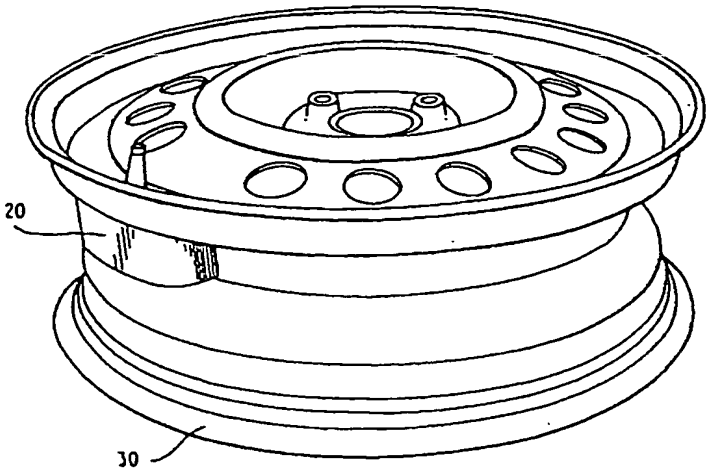
【第1図】


100
150
タイヤ外
アンテナ
180
アンテナ
整合回路
140
RF(無線周波
数)増幅器
130
120
発振器
符号器/タイマ
170
圧力スイッチ
160
学習モードスイッチ
SAW(表面弾性波)
共振器
110
バッテリ
システム送信機
200
270
DIC(ドライバ情報
コンソール)インタフェース
DIC(ドライバ情報
コンソール)へ
計器盤スイッチ
従前
現在
250
マイクロ
コントローラ
260
水晶体
240
データ調整部
220
再生受信機
230
SAW(表面弾性波)
周波数制御装置
電力調整回路
アンテナ
210
システム受信機

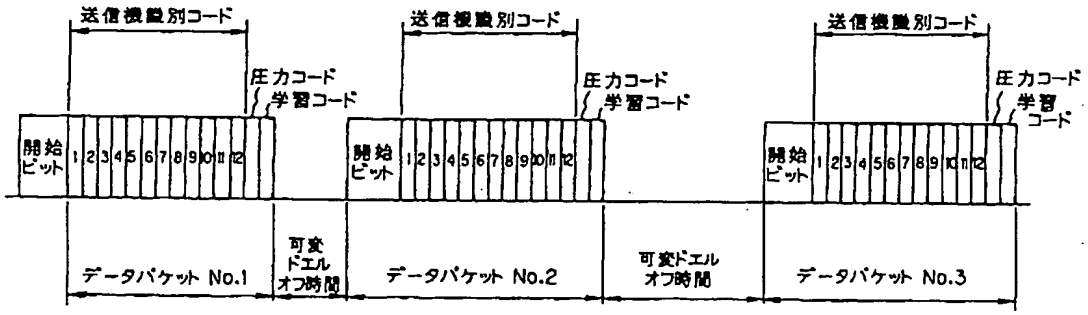
【第２図】



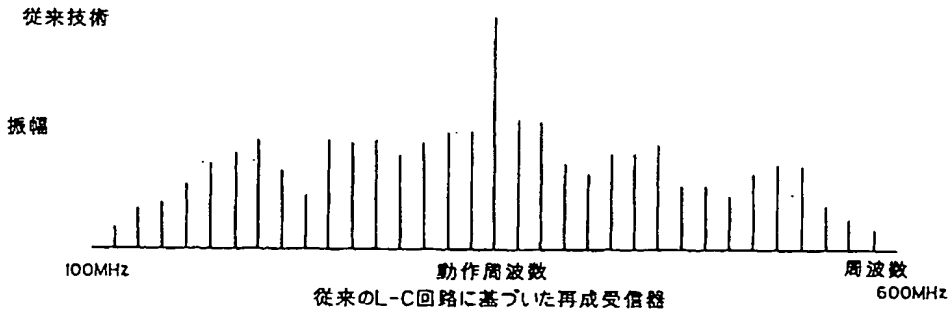
【第３図】



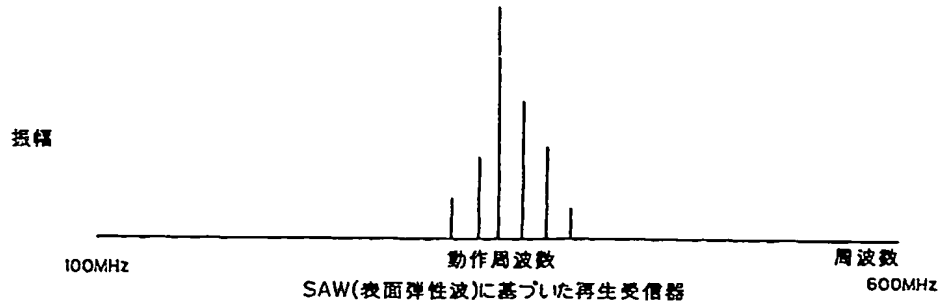
【第５図】



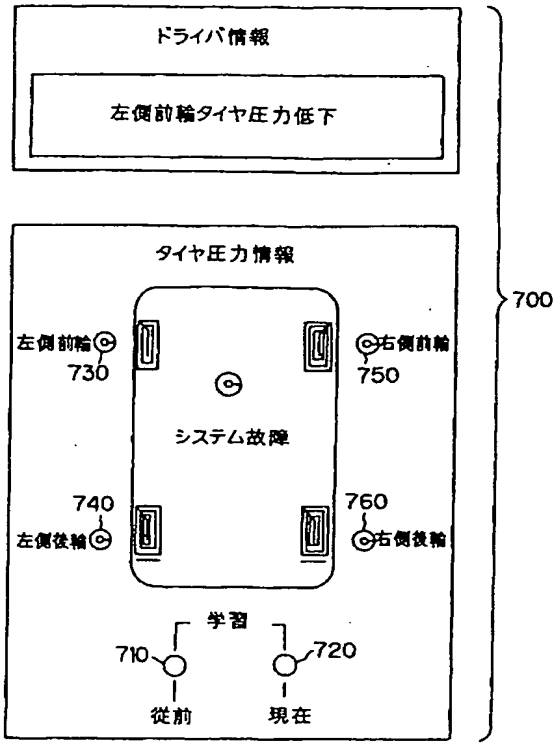
【第６（Ａ）図】



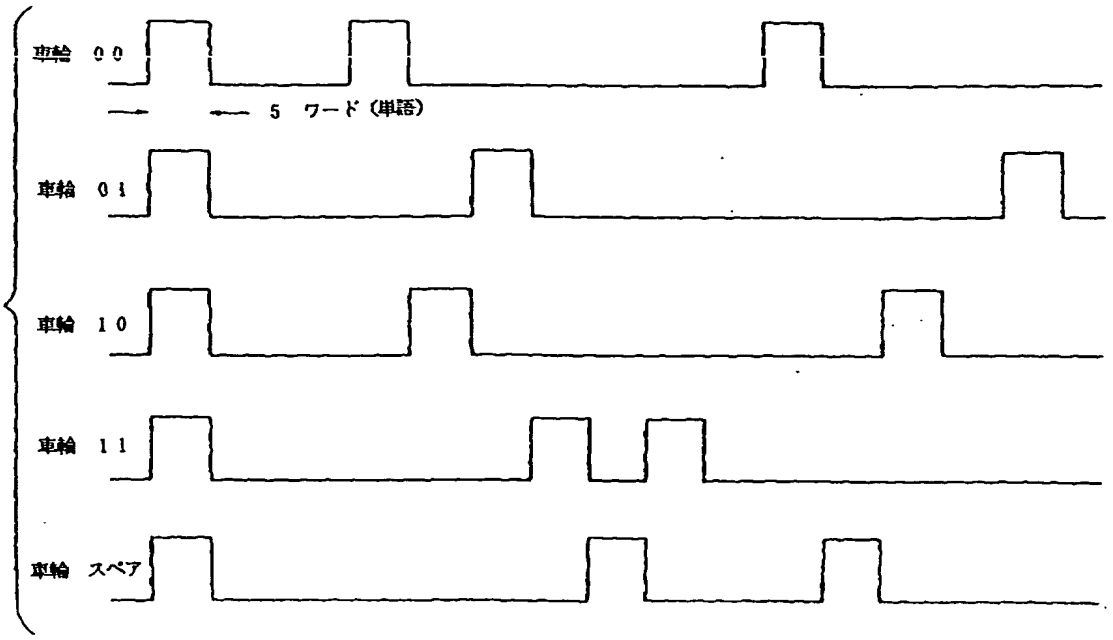
【第６（Ｂ）図】


振幅
100MHz
動作周波数
周波数
600MHz
SAW(表面弾性波)に基づいた再生受信器

【第７図】


ドライバ情報
左側前輪タイヤ圧力低下
タイヤ圧力情報
700
左側前輪
730
右側前輪
750
システム故障
740
左側後輪
760
右側後輪
学習
710
720
従前
現在

【第８図】



[11] Japanese Patent No. 2639856
[24] Issue Date: May 2, 1997
[21] Japanese Patent Application No. 6-504795
[86] [22] Filing Date: March 11, 1993
[65] Publication Number: 8-505939
[43] Publication Date: June 25, 1996
[86] International Application No. PCT/US93/01995
[87] International Publication No. WO94/20317
[87] International Publication Date: September 15, 1994
[73] Patentee: Schrader Automotive, Inc.
[72] Inventor: Robinson, Jerry, H., III
[54] Title of the Invention: Remote Tire Pressure Monitoring System Employing Coded Tire Identification And Radio Frequency Transmission, And Enabling Recalibration Upon Tire Rotation Or Replacement

* * * * *

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CLAIMS

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(57) [Claim(s)]
[Claim 1] In the automobile which has two or more wheels in which at least one tire was attached, respectively It has a display interface for inflation pressure force monitoring system to direct the unusual inflation pressure force inside said automobile, furthermore, this system is equipped with detection/transmitting means equipped with each following means for said every tire, i.e., this detection/transmitting means A means to detect a pressure, and a means to generate the signal which shows each temperature-compensation pressure of said tire, A means to identify uniquely each of said tire, and the location on said automobile while encoding said signal and generating a coded signal, Having a means to transmit said coded signal, and a means by which said system receives said coded signal further, A means to decode said coded signal and to generate the status signal according to it, In said inflation pressure force monitoring system which changes having a means to offer the display which shows each low voltage force and location of said tire, according to said status signal — since — Said detection/transmitting means is attached in the interior of said tire, When said system changes the tire of said automobile, it has the means which carries out recalibration of said system so that said system may re-acquire the information about each location of said tire, The push button which the means which carries out recalibration of said system coordinated with said microcontroller and a means to offer said display, Said microcontroller is programmed to store the location of said tire of said automobile by pushing a push button in a predetermined way in preparation ****** and this case in the first half, And the means which carries out recalibration of said system to each of said tire It has the magnetic actuation switch attached near said detection/transmitting means. This magnetic actuation switch is operated according to existence of the field of that near, and said switch operates in relation to moreover pushing said push button in said predetermined way in this case. By this Said system characterized by programming said microcontroller to store the location of said tire of said automobile.
[Claim 2] The system given in the 2nd term of a claim by which a means to offer said display is characterized by what it consists of a driver information console and said push button, and said driver information console also offers another information about actuation of said automobile for.
[Claim 3] The system given in the 1st term of a claim characterized by what said means to encode consists of an application-specific integrated circuit (ASIC), and said coded signal contains the identification code of a multibit for.
[Claim 4] The system given in the 5th term of a claim characterized by what said multibit identification codes are 12 bit codes.
[Claim 5] The system given in the 5th term of a claim characterized by what said multibit identification codes are 20 bit codes.
[Claim 6] The system given in the 5th term of a claim characterized by what said multibit identification codes are 24 bit codes.
[Claim 7] The system given in the 1st term of a claim characterized by what said means to encode consists of an application-specific integrated circuit (ASIC), and said coded signal contains the 1-bit pressure code which shows the condition of the inflation pressure force for.
[Claim 8] The system given in the 1st term of a claim characterized by what said coded signal contains for the 1-bit study code which shows whether the information to which said detection/transmitting means acts as the professor of said means which carries out recalibration is offered so that said means to encode may consist of an application-specific integrated circuit (ASIC) and a system may be made to re-acquire the information about each location of said tire.
[Claim 9] The system given in the 1st term of a claim by which said dwell time amount is characterized by what said means to encode consists of an application-specific integrated circuit (ASIC), said application-specific integrated circuit (ASIC) has a means to establish dwell time amount between the outputted coded signals, and said coded signal is determined for based on the identification code of said multibit including the identification code of a multibit.
[Claim 10] The system given in the 11th term of a claim by which said multibit identification code is characterized by what is been 12 bit codes.
[Claim 11] The system given in the 11th term of a claim by which said multibit identification code is characterized by what is been 20 bit codes.
[Claim 12] The system given in the 11th term of a claim by which said multibit identification code is characterized by what is been 24 bit codes.
[Claim 13] It is the exchanger which has housing in which a means to detect said pressure has the open end section

which is closed by the septum and demarcates **. The converter by which the aforementioned room was filled up with desiccation nitrogen and the septum side which does not counter said desiccation nitrogen was exposed to the interior of said tire, If it is the usually closed switch which has the first and the second contact, said second contact coordinates with said septum and one pressure in said tire falls below in a predetermined value, said septum so that said usually closed switch may be opened The system given in the 1st term of a claim characterized by having the switch which moves in the direction which separates from said first contact.

[Claim 14] The system given in the 1st term of a claim by which a means to generate said signal is characterized by what is consisted of surface-acoustic-waves (SAW) equipment.

[Claim 15] The system given in the 3rd term of a claim by which a means to receive said coded signal is characterized by what is consisted of a regenerative receiver and a surface-acoustic-waves (SAW) frequency controller.

[Claim 16] The system given in the 1st term of a claim by which a means to decode said coded signal is characterized by what is consisted of a microcontroller.

[Claim 17] Furthermore, the system given in the 1st term of a claim characterized by having two or more dc-battery means for supplying power to each of said detection/transmitting means.

[Translation done.]

* NOTICES *

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2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
Background of invention This invention relates to the system for supervising the inflation pressure force of an automobile. Especially this invention relates to the inflation pressure force monitoring system which transmits to the receiver which attached in the automobile the information coded uniquely, and is displayed on a driver by forming a dc-battery actuation pressure sensor in each wheel according to an individual.
The method of directing the inflation pressure force is variously learned for the conventional technique. The inflation pressure force sensor which offers the information on the inflation pressure force by which temperature compensation was carried out is used for these approaches.
The compensation over a temperature change is important. That is, since a tire gets hot as air expands with temperature and an automobile operates for a long time, the indication of a pressure becomes extremely high when temperature compensation is not made. Similarly, especially as for the cold time of climate, the indication of the inflation pressure force becomes low. It is necessary to standardize the low indication also with these high or actual twists to constant temperature.
In almost all cases, the conventional temperature-compensation approach used electronic fluctuation of an inflation pressure force sensor output. The example is indicated by U.S. Pat. No. 4567459, No. 4703650, and No. 4966034.
The conventional technique has the various well-known approaches for connecting inflation pressure force information to a driver further automatic in the company. There are a tuning circuit and a radio transmitter as these approaches. The former example is indicated by the United States patent mentioned above. The example of the approach using a radio transmitter is indicated by a U.S. Pat. No. 4510484 number, No. 4554527, and No. 5061917.
Well-known inflation pressure force monitoring system has some which coded the digital value concerning each tire of an automobile. The example of this approach is indicated by U.S. Pat. No. 5001457 and U.S. Pat. No. 5061917 mentioned above.
By the time it might **** the integrated-circuit technique and the power generation technique to the small integrated circuit with the long lasting dc-battery, they progressed. The example of the system which attached the dc-battery actuation transmitter in the wheel of an automobile is indicated by U.S. Pat. No. 4978941. The conventional remote inflation pressure force monitoring system has some faults. In order to perform a right display to an instrument panel into these systems in the first place, there are some which are once proofread at the time of an automobile assembly, but in these systems, in case standard maintenance of a tire shift of an automobile etc. is received, the problem resulting from having to carry out recalibration of the system is not taken into consideration. Moreover, it is not thought that the problem of exchange of the damaged transmitter and the problem of the proofreading accompanying exchange are also taken into consideration. Furthermore, a system will spread as the assembly cost of such a system falls. Consequently, when a code overlaps between different systems, pressure indication will be accidentally received by the receiver of another automobile which is present in near from the tire of one automobile, and it will be reported on the console of another automobile.
Moreover, although mind has been conventionally paid to selection of suitable transmit frequencies in order to avoid the interference from other sources of a radio frequency, the characteristic problem has arisen in remote control, such as a keyless entry system system carried out extensively increasingly.
Another problem considered not to be taken into consideration by the conventional system is concerned with evasion [exhausting / of the transient at the time of actuation without low voltage force indication / exhausting / and / the transmitter before installation / dc-battery / dc-battery].
When tires are changed or exchanged, to offer simply study or the inflation pressure force monitoring system which can carry out the relearning is desired in the tire location on the automobile. moreover, the same system on other automobiles — or to offer the system which is not influenced by other radio frequency generative systems automatic in the car [, such as a keyless entry system system,] is desired. Furthermore, while using a newer long lasting power source, by normal operation, to offer the inflation pressure force monitoring system using the temperature-compensation pressure sensor technique for which it does not depend on power is desired that power should be saved.
Outline of invention It is offering the remote inflation pressure force monitoring system which adopted the code of a proper as the transmitter which the purpose of this invention coordinates with a receiver in view of having mentioned above.
It is offering the remote inflation pressure force monitoring system which avoided the interference from the neighboring source of radio-signal generation regardless of whether another purpose of this invention being related

to the specific automobile concerned.
Still more nearly another purpose of this invention is offering the remote inflation pressure force monitoring system which makes recalibration of a receiver possible after the shift of a tire.
Still more nearly another purpose of this invention is offering the remote inflation pressure force monitoring system which makes consumption of a dc-battery the minimum.
According to these purposes and the other purposes, original binary code is used for the system of this invention to each transmitter used by the automatic in the car one. This code is the frequency which is not influenced by other RF (radio frequency) generative systems of an automobile top (for example, a keyless entry system system or an automobile alarm operation system) or the neighborhood (for example, another remote inflation pressure force monitoring system on the next automobile), and is transmitted by laying on top of an amplitude modulation RF carrier signal using the equipment based on surface acoustic waves (SAW). What is necessary is just to push the carbon button on a driver information console, in order to carry out recalibration of the receiver of an automobile after the shift of a tire according to the location of the wheel (therefore, exchanged transmitter) for which it was exchanged.
Moreover, by the usual actuation, the mechanical temperature-compensation pressure sensor which does not consume power is used for the system of this invention. If a pressure falls below in a predetermined value, a switch contact will open and a signal will be sent out to a driver information console.
Easy explanation of a drawing The purpose and the description of the above of this invention and others are hereafter explained to a detail through the suitable example shown in the accompanying drawing. Drawing 1 is the block diagram of the reception concerning the suitable example of this invention, and a sending set.
Drawing 2 is drawing showing the physical configuration of a sending set.
Drawing 3 is drawing showing physical arrangement of the sending set in the drop center of a wheel.
Drawing 4 is drawing showing the pressure switch adopted in the suitable example.
Drawing 5 is a timing diagram which shows the transmit timing of each data packet from a sending set to a receiving set.
Drawing 6 is the comparison Fig. showing the engine performance of a receiver based on the surface acoustic waves (SAW) of this invention as compared with the engine performance of the conventional receiver.
Drawing 7 is the example of arrangement of a driver information console (DIC) drop.
Drawing 8 is the timing chart showing how the inflation pressure force information on each wheel is transmitted to a receiver without contention.
Detailed explanation of a suitable example Drawing 1 is the block diagram of the inflation pressure force remote monitoring system of this invention, and the system sensor / transmitter 100 formed for every tire of an automobile are shown with the system receiver 200 here. Each sensor/transmitter are attached behind the conventional screw-thread type tire valve, and as shown in drawing 2, it constitutes the whole assembly 20. A valve functions as an antenna for transmitting the encoded tire discernment and pressure information to a receiver 200 so that it may mention later.
Before moving to detailed explanation of an electronic circuitry, the mechanical side face of equipment is explained a little. The electronic circuitry of a sensor/transmitter is held in nylon housing filled up with glass, and in order to protect from mechanical oscillation, dirt, etc. further, it is inserted in with the insulating material. By the starting configuration, the unit in a tire with a low manufacturing cost is obtained that it is easy to install. Total weight of equipment is made as small as possible in order to abolish the need of attaching counterweight in the wheel which attaches the equipment concerned. Moreover, he can attach equipment easily in the drop center cavity of a wheel, and is trying to protect from tire removal equipment by making the dimension of equipment as small as possible. Drawing 3 shows an example which attached the assembly 20 in the drop center of a wheel 30 in this way.
Each sensor/transmitter contain the lithium power source which can continue supplying power for ten years. Since the life of a power source is long, it becomes possible to attach everlastingly, and exhaust a power source and it is not changed.
By using surface fittings, the electronic circuitry is designed so that a tooth space may be maintained. Although the printed circuit board (PCB) for electronic circuitries is formed from flame resistance fiber glass FR-4 ingredient in the suitable example, other ingredients may be used for it if needed. The component outside a substrate is connected to the main PCB using distorted release through tube connection.
Sensor 400 the very thing which showed the outline to drawing 4 is mechanical contrivance which emits a low voltage report through opening of a switch. As the following things show, although a sensor does not consume power, this is the description important for the reinforcement of equipment. In drawing 4, a sensor 400 has the pressure diaphragm 410 which consists of beryllium 1 copper alloy. The body 420 is formed from brass. Glass / seal 430 between metals encloses a stanchion 440, and closes ** 450 formed with the diaphragm 410 and the body 420. ** 450 is filled up to the pressure which is slightly less than the pressure which needs the desiccation nitrogen which has the same temperature expansion property as air to produce a low inflation pressure force report. For example, in the case of the reserve tire which carried this pressure in 25psi(s) (1.76kg/cm2) and a trunk by 20-degree Centigrade in the case of the tire of an automobile, it is made into 60psi (4.22kg/cm2). In the case of the tire of the class of a truck and others, pressures may differ. Therefore, the distant one side of a diaphragm 410 is exposed to nitrogen, and the nearer one side is exposed to the air in a tire.
A stanchion 440 has the contact 445 of the gold which usually touches the diaphragm. If the pneumatic pressure in a tire decreases to below a predetermined value, the nitrogen in ** 450 will energize a diaphragm in the direction

which separates from a contact 445, and will open a switch. Since this switch is an inactive component, as mentioned above, it does not consume power.
A system will emit warning, if the pressure of the tire attached in the automobile descends below to a predetermined value. Furthermore, the system is carrying out the self-monitor and reports malfunction of a system to a user. Furthermore, since data output of a receiver can be performed so that it may suit with the computer for driver information consoles automatic in the car, it can display inflation pressure force information directly on an instrument panel with other actuation information again. In addition, control of the computer for driver information consoles can be used in order to carry out recalibration of the system in a tire shift, so that it may explain below.
If drawing 1 is referred to again, non-field elastic wave (SAW) equipment 110 will function as a primary oscillator in each sensor / transmitter 100, and will emit an amplitude modulation RF (radio frequency) carrier signal. The application-specific integrated circuit (ASIC) 130 is constituted so that the output-data rate of the coding network of equipment may be set up (after-mentioned).
Surface-acoustic-waves equipment 110 was the source of a frequency stabilized essentially, and since frequency compensation was continued and carried out to an extensive temperature requirement, it was adopted. This compensation property is especially important when equipment needs to give exact wireless transmit frequencies irrespective of whether a tire is very cold or to be hot. Surface-acoustic-waves equipment 110 sends the low-power output RF signal selected so that the interference to other sources of a frequency might serve as min. Moreover, this selection is based also on the need of constituting the communication path stabilized through the minor diameter edge property of an automobile. Therefore, the frequency of about 418.0MHz was selected in the suitable example.
An application-specific integrated circuit 130 generates the data which should be transmitted as a serial data signal according to disconnection of the pressure switch of drawing 4. As shown in drawing 5, a serial data signal contains the transmitter discernment (ID) code of a multibit, a 1 bit pressure code, and a 1-bit study code. The number of bits of transmitter identification code is decided according to the number of original codes required in order to identify each transmitter correctly. In one example, although the die length of identification code is 12 bits, it is good also as 20 bits or 24 bits if needed. A start bit is preceded with each transmitter identification code. An application-specific integrated circuit 130 generates a TTL (transistor-transistor logic) level signal required to drive an oscillator 120. The study mode switch 160 which operates magnetically, the pressure switch 170 mentioned above, a multilayer printed board trace switch required to set up each transmitter code programmed by each transmitter at the time of manufacture, and ** are contained in the input section of an application-specific integrated circuit 130. The transmitter itself is designed according to the requirement of FCC (U.S. communication link committee).
Another description of the code programmed by the application-specific integrated circuit 130 relates to transmit timing. As shown in the timing chart of drawing 8, the dwell period, i.e., a "off" period, is established between the continuous data packets at arbitration. The indexing of this "off" period is carried out to the specific transmitter code programmed by each transmitter 100 at the time of manufacture. Consequently, they make it hard for two transmitters not to transmit to coincidence at all, and to happen interference of transmitters, or the collision of a radio frequency. This description is especially important when this system is realized by the whole fixed automatic vehicle group, for example. Possibility that the transmitter of a certain automobile in the automatic vehicle group concerned will send the low voltage report which was mistaken in another automobile in this way falls.
The description of 12 bit codes makes possible what the signal with which the receiver of each system was sent from the transmitter of the system concerned, and the signal from a transmitter attached in other automobiles are identified for again.
The buffer of the RF (radio frequency) signal output is amplified and carried out with the latter amplifier 140 with the application-specific integrated circuit supply code put on it. amplifier 140 can generate the RF signal which has the amplitude suitable for offering a communication link effective for the receiver which operates in the PAX interior of a room of an automobile — it is simple and is efficient low cost common emitter amplifier. The data signal from the encoder application-specific integrated circuit of a transmitter turns this amplifier stage on and off. Consequently, the Pulse-Density-Modulation signal which transmits the digital information put on the amplitude modulation RF subcarrier is acquired.
The output of amplifier 140 is correctly adjusted on the valve rod 150 of a tire. Since it exposes from a wheel and this valve rod 150 forms an ideal radio-signal transmitting antenna, it is the especially suitable antenna. The antenna-matching circuit 180 considers maximum RF power movement magnitude. When a hold **** antenna is completely used in a tire, the amount of energy of a receiver decreases and a much more powerful transmitter or a receiver with still higher sensibility is needed. The die length of a valve rod is shortened in consideration of the clock frequency of a transmitter. Therefore, the suitable impedance matching circuit 180 is formed so that all radio frequencies may be guided at an antenna. Moreover, in order to insulate a valve rod from the conductive wheel with which is isolated from water dirt or it is equipped, special non-conductive coating has been performed to the outside of a valve.
next, when the receiver 200 of drawing 1 is referred to, the function of this receiver is receiving information from each transmitter 100 namely, — from each wheel in equipment, decoding the information concerned, sending to a driver information console further, and displaying on an automobile operator. Each receiver 200 is a super-low power playback mold receiver which operates on the frequency of the corresponding transmitter 100. The receiver 200 is designed as there are other radio frequency receivers and compatibility which are operating by the same automatic in the car one. There is a receiver applied to the keyless entry system system (equipment which opens and closes a

door lock, without using a key) carried, for example in the automobile as such a receiver.
The receiver 200 has taken in the playback design which effectiveness presents high sensitivity well by low cost. Like a transmitter 100, the frequency controller based on surface acoustic waves is being used for a receiver 200, and it is stabilizing clock frequency effectively in consideration of both temperature and mechanical oscillation. Moreover, since the characteristic spectrum noise essentially generated by the regenerative receiver around desired clock frequency closes the design based on surface acoustic waves (SAW) and it can perform eye ** certainly, it is advantageous. This result is shown in the graph of drawing 6.
the clock frequency circumference is trustworthy — shutting up — the compatibility of the receiver concerned to other receivers automatic in the car is raised. The design approach of a receiver based on these surface acoustic waves (SAW) also presents good selectivity again.
As shown in drawing 1, an antenna 210 receives a signal from the valve rod antenna 150. The antenna 210 attached in the closing container of a receiver 200 has the high sensibility in both vertical and horizontal polarization mode in order to decrease the effect of the polarization mismatching between a system transmitter and a receiver.
An input signal is sent out to the regenerative receiver 220 which has two incomes with a surface-acoustic-waves (SAW) frequency controller, and operates as mentioned above. The datcoord section 240 is formed in the output side of a receiver 220 in order to decrease signal degradation which may be produced by the external noise. The output of the datcoord section 240 is supplied to a microcontroller 250. In the suitable example, although this microcontroller is 8 bits, more powerful and in order to make it low cost, it may consider use of other much more powerful microcontrollers for a processor.
A microcontroller 250 receives a timing signal from a lens 260, decodes the information within a signal, and sends it to the bus interface 270 further. The bus interface 270 interprets the decoded information according to a specific driver information console automatic in the car. If the manufacturer of an automobile is different, a bus interface will also become each manufacturer's original thing so that the designs of a console may also differ, respectively. Since it is available components separately, it is not necessary to explain an interface in full detail here. However, probably an interface usually consists of four pieces or five low cost external passive elements with one integrated circuit.
When supplied by the automobile manufacturer, driver information console 700 the very thing which showed an example to drawing 7 may consist of, two or more lamps (LED), i.e., light emitting diode, and may consist of liquid crystal displays (LCD).
Moreover, a receiver 200 has a wheel shift recalibration switch interface concerning a microcontroller 250. As already stated, the recalibration of a system is required in order to act to a system as the "professor" of the new wheel location resulting from the shift of a tire. In practice, the same structure may be used in order to act to a system as the "professor" of the early wheel location (in for example, the case of a four-flower automobile wheel location of left-hand side anterior part and a posterior part, right-hand side anterior part, and a posterior part) at the time of manufacture.
The power equalization circuit 280 is shown in the top left corner of the receiver 200 of drawing 1. This circuit constitutes the voltage regulator which decreases and adjusts the standard voltage (for example, 13.8V) impressed by the electric system of an automobile to stable 5.0V used by a radio frequency microcontroller circuit and the driver information console interface circuitry. According to another description of this invention, each system receiver "can learn" the code related to each transmitter. This description contributes to the collision-prevention function of a radio frequency in which it explained previously, further. Moreover, it acts a code required at the time of manufacture as the "professor" of each receiver. When drawing 7 is referred to, the driver information console 700 has two micro carbon buttons 710 and 720 located the inflation pressure force alarm display lamp 730 thru/or near 760. In a suitable example, in order to make a system into "study" mode for about 60 seconds, two carbon buttons are pushed for 3 seconds at coincidence. In the meantime, he admires a receiver to reception of the characteristic learning mode signal from one of the transmitter attached in the tire. In order to send a learning mode signal, the sweep of the powerful magnet is carried out on the outside of each automobile tire near [each] the transmitter. Each transmitter will be returned to the system receiver integrated in the study signal so that a new transmitter code group may be learned, if the magnetic signal produced as a result is received.
Sequential [to which each transmitter acts as the professor of the receiver] (namely, sequential [to which a magnet passes each wheel]) determines the current position of each wire on an automobile, for example, a front left wheel, a rear left wheel, a front right wheel, a rear right wheel, etc. According to this process, the starting position proofreading in the case of installing a system in the assembly plant of an automobile becomes easy.
Another function of carrying out the sweep of each transmitter magnetically is decreasing consumption of the remarkable dc-battery before installation, and prolonging the storage life of a transmitter by "awaking" each transmitter from the sleep mode at the time of manufacture.
When a transmitter is damaged, in order to change a transmitter again, a receiver may be formed so that it may sympathize with transmitter code with an another common shift code etc.
"Study" function is important not only at for example, the time of manufacture but the time of everyday maintenance of an automobile, for example, the shift of a tire. Since a receiver 200 matches the code of each of that transmitter with the location (for example, a front left wheel, a rear left wheel, a front right wheel, a rear right wheel) of each transmitter on an automobile and is programmed at the time of the shift of a tire, the relearning of each location is needed. When this relearning was not performed and the inflation pressure force of a specific tire decreases to a transient, the display on a driver information console will give the wrong information.
As shown in drawing 7, label attachment of the two micro carbon buttons 710 and 720 is carried out with old

["old"] and the "present", respectively. Immediately after a tire shift, a maintenance engineer pushes the "old" carbon button 710 repeatedly until the tire location of a request on the driver information console 700 lights up. Thus, after deducing an old location, an engineer pushes the "current" carbon button 720 until the current position of a tire lights up on a console 700. If a "current" carbon button is opened, after old and the current location of a tire with arbitration will blink continuously, a pause (for example, 0.5 seconds) displays the recalibration which should be continued and stored. This information can also be displayed on a liquid crystal display (LCD). Recalibration of this new tire location is carried out to the system receiving inside of a plane by pushing old and a current carbon button at the short-time coincidence for less than 3 seconds. This procedure is repeated for every tire of a system, and if old and the present carbon button are pushed, for example for 10 seconds at coincidence and recalibration of the last tire is carried out, it will be ended.

As an example, in a standard tire shift, a front-wheel tire is moved to a rear wheel tire, a rear wheel tire is moved to a front-wheel tire, and it replaces with. At the first recalibration step, the "old" carbon button 710 is pushed until the front left wheel lamp on the driver information console 700 lights up. Next, the "current" carbon button 720 is pushed until the rear left wheel lamp on a console 700 lights up. Furthermore, a push on the carbon button of old and present both stores the location of the transmitter which moved to the rear left wheel from the front left wheel in a receiver 200.

As mentioned above, although this invention has been explained to a detail based on a suitable example, it is clear to this contractor that various modification and corrections can be made, without deviating from the range and pneuma of this invention. Therefore, it should be understood as this invention being limited by only the attachment claim.

[Translation done.]

* NOTICES *

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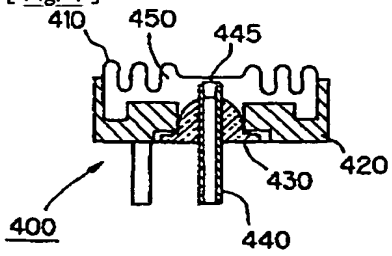
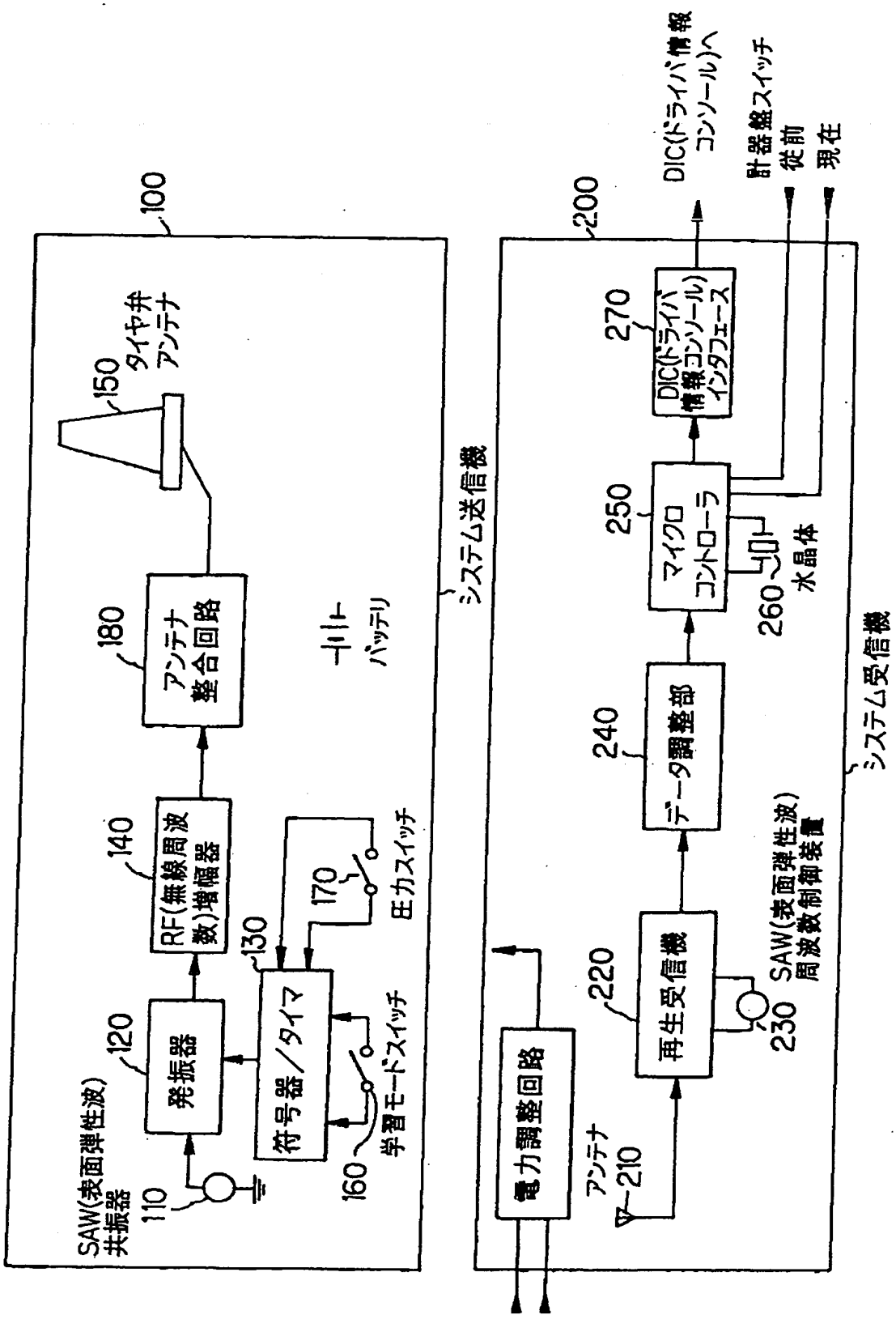
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

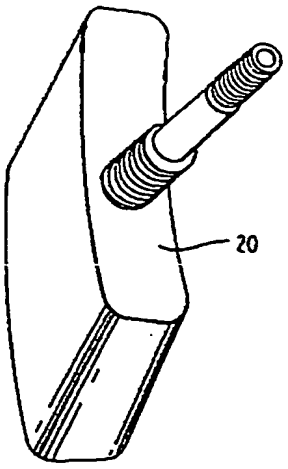
[Fig. 4]



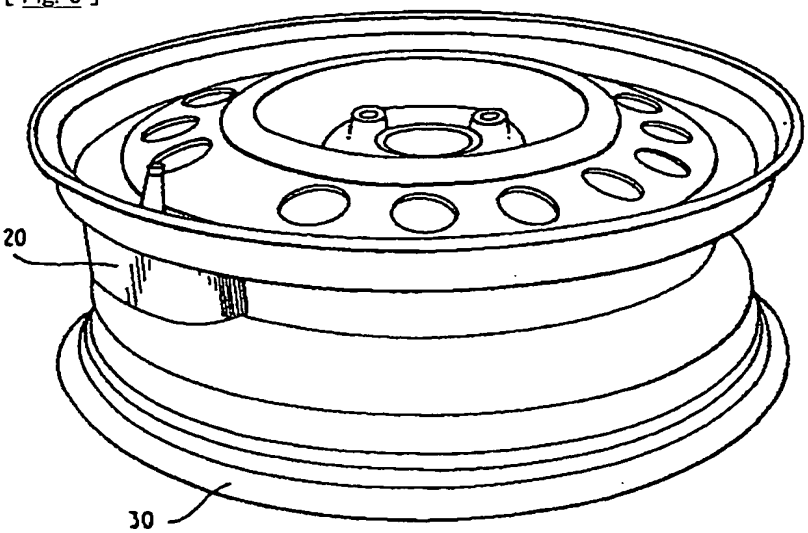
[Fig. 1]


100
タイヤ弁
アンテナ
150
180
アンテナ
整合回路
バッテリ
システム送信機
140
RF(無線周波
数)増幅器
170
圧力スイッチ
130
120
発振器
符号器/タイマ
学習モードスイッチ
160
SAW(表面弾性波)
共振器
110
200
DIC(ドライバ情報
コンソール)へ
計器盤スイッチ
従前
現在
270
DIC(ドライバ
情報コンソール)
インタフェース
250
マイクロ
コントローラ
260
水晶体
240
データ調整部
220
再生受信機
230
SAW(表面弾性波)
周波数制御装置
システム受信機
電力調整回路
アンテナ
210

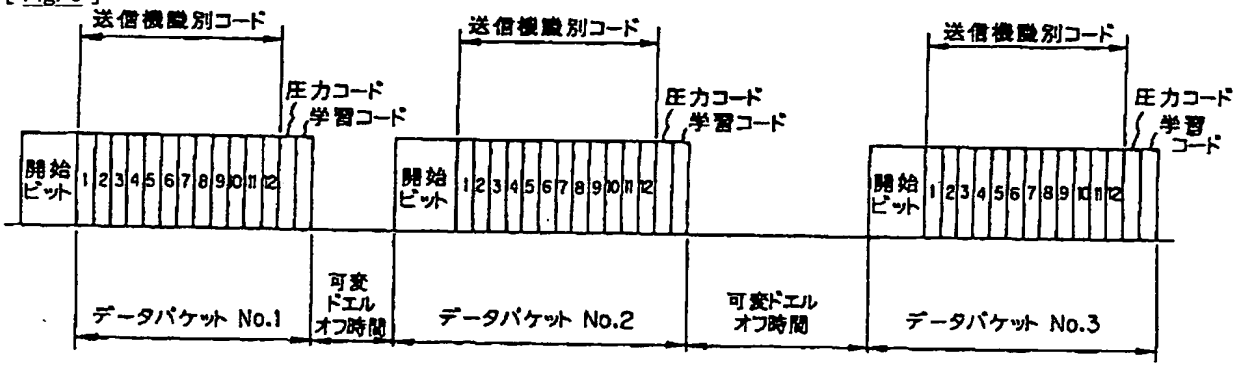
[Fig. 2]



[Fig. 3]

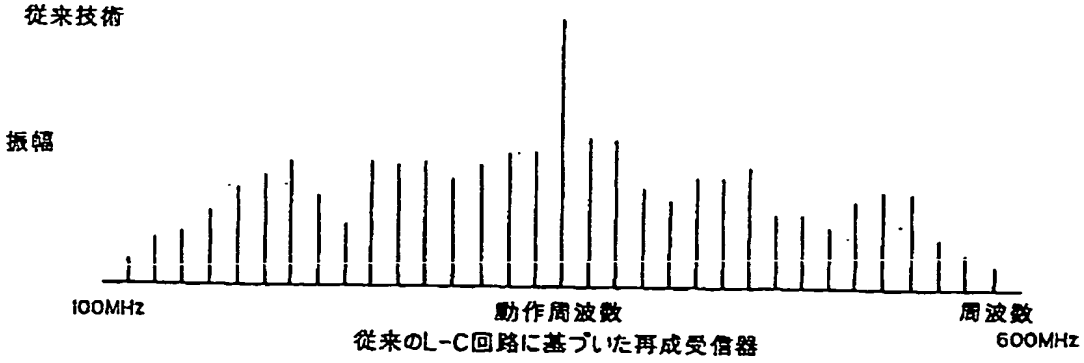


[Fig. 5]



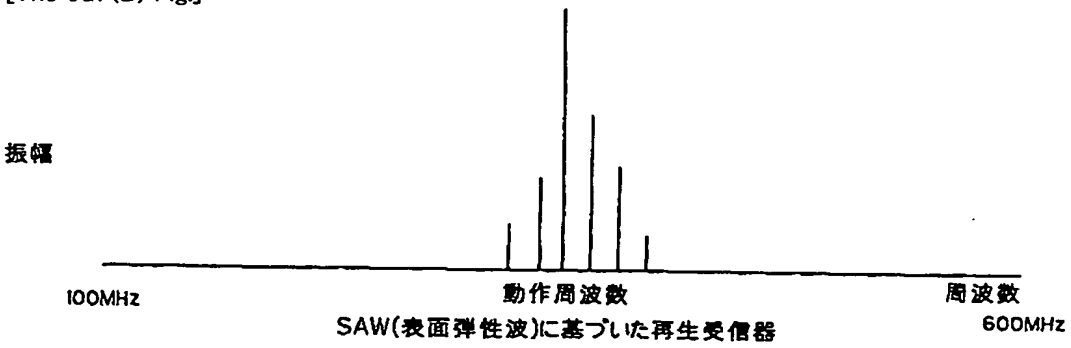
[The 6th (A) Fig.]

従来技術



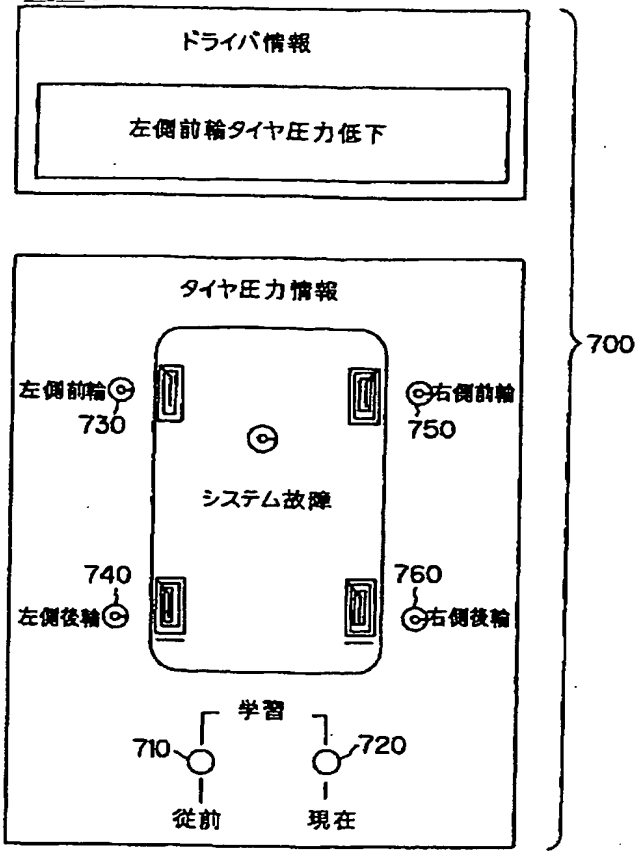
従来のL-C回路に基づいた再成受信器

[The 6th (B) Fig.]

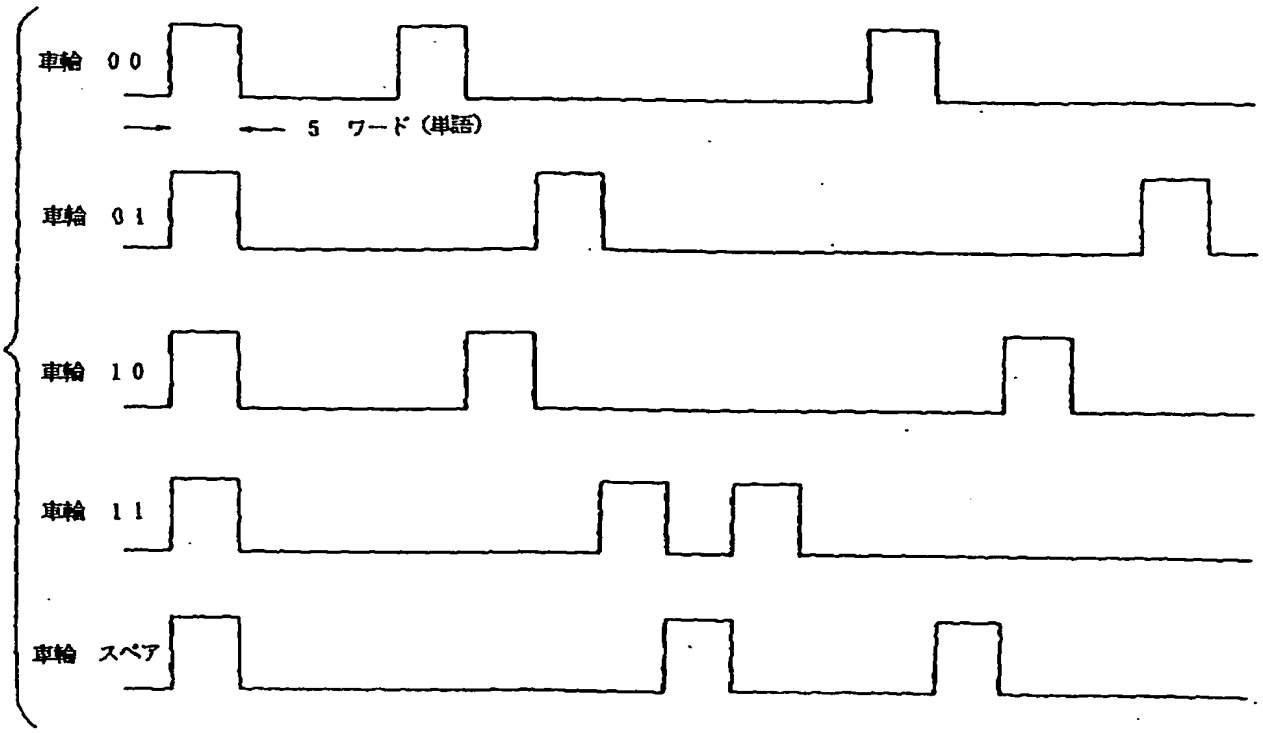


SAW(表面弾性波)に基づいた再生受信器

[Fig. 7]



[Fig. 8]



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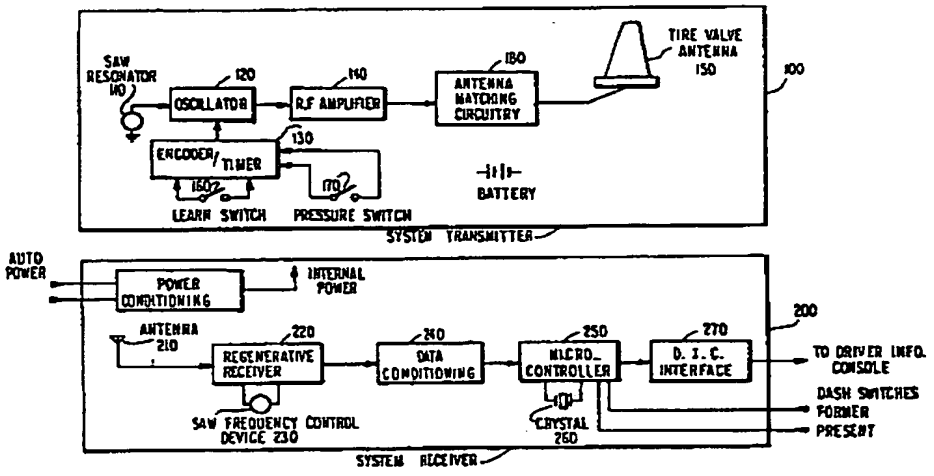

(57) Abstract

A system for indicating low tire pressure in vehicles, in which each vehicle wheel has a transmitter (100) with a unique code. A central receiver (200) in the vehicle is taught, at manufacture, to recognize the codes for the respective transmitters (100) for the vehicle, and also a common transmitter code, in the event one of the transmitters (102) needs to be replaced. During vehicle operation and maintenance, when the tires are rotated, the system can be recalibrated to relearn the locations of the transmitters. The transmitters (100) employ surface acoustic wave (SAW) devices (110). An application specific integrated circuit (ASIC) encoder (130) in each transmitter (100) is programmed at manufacture, in accordance with its unique code, to send its information at different intervals, to avoid clash between two or more transmitters (100) on the vehicle. The transmitters (100) are powered by long-life batteries.

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REMOTE TIRE PRESSURE MONITORING SYSTEM EMPLOYING CODED TIRE IDENTIFICATION AND RADIO FREQUENCY TRANSMISSION, AND ENABLING RECALIBRATION UPON TIRE ROTATION OR REPLACEMENT

BACKGROUND OF THE INVENTION

The present invention relates to a system for monitoring pressure of tires in a wheeled vehicle. In particular, the invention relates to a tire pressure monitoring system employing individual battery-powered pressure sensors in each wheel, for transmitting uniquely coded information to a receiver mounted on the vehicle for display to a vehicle operator.

The art is replete with various known approaches to providing indications of tire pressure. These approaches include tire pressure sensors which provide temperature-compensated tire pressure information. Compensation for changes in temperature is important. Because air expands with temperature, and because tires get hotter the longer a vehicle is operated, failure to provide compensation for temperature can yield inordinately high pressure readings. Likewise, particularly cold weather can yield low tire pressure readings. These high and low readings need to be normalized to a constant temperature.

For the most part, known approaches to temperature compensation have employed electronic alteration of tire pressure sensor outputs. Examples may be found in USP 4,567,459, 4,703,650, and 4,966,034.

The art further includes a number of known approaches for communicating tire pressure information to a vehicle operator inside the vehicle. These approaches include tuned circuits and radio transmitters. Examples of the former may be found in the just-mentioned U.S. patents. Examples of radio transmitter approaches may be found in USP 4,510,484, 4,554,527, and 5,061,917.

Another aspect of known tire pressure monitoring systems relates to the coding of digital values associated with respective tires on a vehicle. Examples of such approaches are found in USP 5,001,457 and in just-mentioned USP 5,061,917.

Integrated circuit technology and power generation technology have progressed to the point where long-life batteries can power small integrated circuits. An example of a system employing battery-powered transmitters on vehicle wheels is found in USP 4,978,941.

Known remote tire pressure monitoring systems are deficient in several respects. First, while presumably some of these systems are calibrated somehow during vehicle assembly to enable proper display on, for example, a dashboard console, these systems do not address the problem arising from the need to recalibrate the systems when the vehicles undergo standard maintenance such as tire rotation. The problem of replacement of damaged transmitters, and of calibration of the replacements, does not appear to be addressed, either.

Another deficiency relates to the coding of transmitters for associated receivers. As the cost of assembly of such systems decreases, the systems will proliferate. If there is overlapping of codes among different systems, false pressure readings from tires of one vehicle could be reported on the console of another vehicle in close proximity, having been received erroneously by a receiver on that other vehicle.

Also, while attention has been paid in the past to selection of appropriate transmission frequencies to avoid interference from other radio frequency sources, particular problems are presented by remote control systems, such as keyless entry systems, which are becoming more and more widely implemented.

Yet another problem which does not seem to have been addressed in known systems relates to battery drain in transmitters prior to installation, and avoidance of excessive battery drain in operation, in the absence of a low pressure reading.

It would be desirable to provide a tire pressure monitoring system which can learn, or relearn, tire locations simply on a vehicle when tires are rotated or replaced. It also would be desirable to provide a system which is not affected by similar systems on other vehicles, or by other radio frequency generating systems within the vehicle, such as keyless entry systems. Further, it would be

desirable to provide a tire pressure monitoring system which takes advantage of newer longer-life power sources, and which uses temperature-compensated pressure sensor technology which is not power dependent in normal operation, so as to conserve power.

SUMMARY OF THE INVENTION

In view of the foregoing, it is an object of the invention to provide a remote tire pressure monitoring system which employs codes which are unique to the transmitters which are associated with a respective receiver.

It is another object of the invention to provide a remote tire pressure monitoring system which avoids interference from nearby radio signal generating sources, whether or not associated with the particular vehicle in question.

It is still another object of the invention to provide a remote tire pressure monitoring system which enables recalibration of the receiver after tire rotation.

It is yet another object of the invention to provide a remote tire pressure monitoring system which minimizes battery drain.

In accordance with the foregoing and other objects, the inventive system employs a unique binary code for each transmitter used in a vehicle. The code is transmitted by superimposing it on an amplitude modulated RF carrier signal using a surface acoustic wave (SAW)-based device, at a frequency which will not be affected by other radio frequency generating systems, either on the vehicle (e.g. a keyless entry system or car alarm activation system) or nearby (e.g. another remote tire pressure monitoring system on an adjacent vehicle). Buttons on a driver information console may be depressed after tire rotation to recalibrate the receiver on the vehicle to account for changed wheel (and hence changed transmitter) locations on the vehicle.

The inventive system employs a mechanical temperature-compensated pressure sensor which does not consume power in normal operation. Switch contacts are opened when tire pressure falls below a predetermined value, causing a signal to be sent to the driver information console.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects and features of the invention now will be described in detail by way of a preferred embodiment, depicted in the accompanying drawings, in which:

Figure 1 is a block diagram of receiving and transmitting apparatus according to a preferred embodiment of the invention;

Figure 2 is a drawing of the physical configuration of the transmitting apparatus;

Figure 3 is a drawing of the physical placement of the transmitting apparatus in a drop-center of a vehicle wheel;

Figure 4 is a drawing of a pressure switch employed in the preferred embodiment;

Figure 5 is a time chart showing timing of transmission of individual data packets from the transmitting apparatus to the receiving apparatus;

Figure 6 is a comparative diagram showing performance of the surface acoustical wave (SAW)-based receiver of the invention as contrasted with that of conventional receivers;

Figure 7 is an exemplary layout of a driver information console (DIC) display; and

Figure 8 is a timing diagram showing how tire pressure information for each wheel can be transmitted to the receiving apparatus without conflict.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

Figure 1 is a block diagram of the inventive remote tire pressure monitoring system, in which a system sensor/transmitter 100, one of these being provided for each tire in a vehicle, is shown in conjunction with a system receiver 200. Each sensor/transmitter is mounted to the back of a conventional screw-in tire valve to provide an overall assembly 20, as shown in Figure 2. As will be described, the valve acts as an antenna to transmit coded tire identification and pressure information to the receiver 200.

Before proceeding to a detailed description of the electronics, some description of the mechanical aspects of the device will be provided. The sensor/transmitter electronics are packaged in a glass-filled nylon housing, and are potted to provide additional protection from mechanical vibration, dirt, and the like. The described mounting makes the in-tire unit easy to install and inexpensive to manufacture. The overall weight of the device is kept to a minimum, so as to reduce or eliminate the need to provide counterbalancing in the wheel in which the device is mounted. Also, by keeping the size of the device as small as possible, the device can be mounted and protected easily within the wheel's drop-center cavity, for protection from tire removal equipment. Figure 3 shows one example of such drop-center mounting of the assembly 20 on a wheel 30.

Each sensor/transmitter uses an internal lithium power source, which can provide continuous power for up to ten years. The power source's long life makes it feasible to provide permanent mounting; the power source is not replaced when it is exhausted.

The electronics have been designed to conserve space by using surface-mounted parts. The printed-circuit board (PCB) for the electronics is made from a flame resistance fiberglass FR-4 material in the preferred embodiment; other materials may be used if desired. The off-board components are connected to the main PCB using strain relief through-hole connections.

The sensor 400 itself, shown schematically in Figure 4, is a mechanical device which provides a low pressure report through the opening of a switch. As will be appreciated from the following, the sensor does not consume any power. This is an important feature for the long operating life of the device. In Figure 4, the sensor 400 has a pressure diaphragm 410 made of a beryllium-copper alloy. The body 420 is made of brass. A glass to metal seal 430 surrounds a post 440, and seals a chamber 450 which is formed by the diaphragm 410 and the body 420. The chamber 450 is filled with dry nitrogen, which has the same temperature expansion characteristics as air, to a pressure just below that necessary to cause a low tire pressure report. For example, this may be 25

psi at 20°C for the tires on the car, and 60 PSI for trunk mounted spares. The pressure may be different for truck or other types of tires. Thus, the far side of the diaphragm 410 is exposed to nitrogen, and the near side is exposed to air within the tire.

The post 440 has a gold contact 445, which normally is in contact with the diaphragm 410. When air pressure within the tire decreases below a predetermined amount, the nitrogen within the chamber 450 forces the diaphragm away from the contacts 445, thus opening the switch. Since this switch is an inactive element, it does not consume any power, as mentioned above.

The system will output an alarm when the pressure in any tire mounted on the vehicle drops below a predetermined point. Further, the system is self-monitoring, and will report any system malfunction to the user. Still further, the data output of the receiver can be made to be compatible with a driver information console computer in a vehicle, so that tire pressure information can be displayed directly on a dashboard readout, along with other operational information. In addition, as described herein, the controls of the driver information console computer can be utilized to recalibrate the system in the event of tire rotation.

Looking again at Figure 1, a surface acoustic wave (SAW) device 110 functions as the primary oscillator in each sensor/transmitter 100, to provide an amplitude-modulated RF carrier signal. An application specific integrated circuit (ASIC) 130 is configured to set the output data rate of the coding circuitry of the device (described below).

The SAW device 110 was selected because it is an inherently stable frequency source, and is frequency compensated over a wide temperature range. This compensation feature is particularly important, given that the device needs to provide an accurate radio transmission frequency whether the tire is very cold or very hot. The SAW device 110 provides a low output RF signal which is selected to provide a minimum of possible interference with respect to other sources. Selection also is based on the necessity of providing a reliable

communications path through small openings characteristic of automobiles. Consequently, in the preferred embodiment, a frequency of approximately 418.0 MHz was chosen.

The ASIC 130 creates data to be transmitted, in the form of a serial data signal, in response to opening of the pressure switch of Figure 4. As seen in Figure 5, the serial data signal contains a multiple-bit transmitter identification (ID) code, a one-bit pressure code, and a one-bit learn code. The number of bits in the transmitter ID code will depend on the number of unique codes necessary to identify the transmitters properly. In one embodiment, the ID code is 12 bits long. However, the ID code may be 20 bits long, or 24 bits long, or longer if necessary. A start bit precedes each transmitter ID code. The ASIC 130 produces TTL level signals necessary to drive the oscillator 120. Inputs to the ASIC 130 include a magnetically-activated learn-mode switch 160, the pressure switch 170 described above, and multiple PC board trace switches necessary to set the individual transmitter code, which is programmed into each transmitter during manufacture. The transmitter itself is designed in accordance with FCC requirements.

Another aspect of the code which is programmed into the ASIC 130 relates to the timing of transmission. As shown in the timing diagram of Figure 8, a random dwell time period, or off period, between consecutive data packets, is provided. This off period is indexed to the specific transmitter code programmed into each transmitter 100 at the time of manufacture. As a result, no two transmitters will transmit at exactly the same time, thus reducing or eliminating the possibility of transmitter interference or RF clash. This feature is particularly important when the inventive system is implemented in an entire vehicle fleet, for example. The likelihood thus is reduced that transmitters in one vehicle in the fleet will provide a false low pressure report to another vehicle.

The uniqueness of the twelve-bit code also contributes to the ability of each system receiver to distinguish signals sent from its own transmitters from those of transmitters mounted on other vehicles.

The RF signal output, with the ASIC-supplied code superimposed thereon, is amplified and buffered in a following amplifier stage 140 which may be a simple, efficient, low-cost common emitter amplifier which can produce an RF signal having an amplitude appropriate for supplying effective communication to a receiver operating within the vehicle's passenger compartment. The data signal from the transmitter's encoder ASIC keys this amplifier stage on and off. The result is a pulse width modulated signal which conveys digital information, superimposed on the amplitude-modulated RF carrier.

The output of amplifier 140 is matched correctly onto a valve stem 150 of the tire. The valve stem 150 is a particularly appropriate antenna, because it is exposed through the vehicle wheel, and hence makes an ideal radio signal radiator. The antenna matching circuitry 180 provides for maximum RF power transfer. It can be appreciated that using an antenna which is contained completely within the tire would reduce the amount of energy at the receiver, thus necessitating either a more powerful transmitter, or a more sensitive receiver. In view of the transmitter's operating frequency, the valve stem is short. Hence, appropriate impedance matching circuitry 180 is provided to ensure that all of the radio frequency is conducted to the antenna. Also, to isolate the valve stem from water dirt, and also to insulate it from the conductive wheel in which it is mounted, a special non-conductive coating is applied to the exterior of the valve.

Looking now at receiver 200 in Figure 1, it is noted first that the function of this receiver is to accept information from each wheel in the device (i.e. from each of the transmitters 100), decode that information, and send it to the driver's information console for display to the vehicle operator. Each receiver 200 is a very low power, regenerative type receiver which operates at the frequency of its associated transmitters 100. The receiver 200 is designed to be compatible with other radio frequency receivers operating within the same vehicle. Such receivers include, for example, that associated with a keyless entry system with which the vehicle may be equipped.

The receiver 200 incorporates a regenerative design because such a design is low in cost, is efficient, and exhibits a high sensitivity. As in the transmitter 100, the receiver 200 uses SAW-based frequency control, thus stabilizing the operating frequency effectively in view of both temperature and mechanical vibration. The SAW-based design also is advantageous because it enables tight containment of the characteristic spectral noise, inherently created by a regenerative receiver, around the desired operating frequency. This result is shown graphically in Figure 6.

The tight containment around the operating frequency enhances the compatibility of the receiver with other receivers within the vehicle. This SAW-based receiver design approach also exhibits good selectivity.

As shown in Figure 1, an antenna 210 receives signals from the valve stem antenna 150. The antenna 210, which is mounted within an enclosure of the receiver 200, is sensitive in both vertical and horizontal polarization modes in order to decrease the effects of polarization mismatch between system transmitters and receivers.

The received signal is provided to regenerative receiver 220, which as described above operates in conjunction with a SAW frequency control device 230. A data conditioning section 240 is provided at the output of receiver 220, to reduce signal degradation which can be caused by external noise. The output of data conditioning section 240 is provided to a microcontroller 250, which in the preferred embodiment is an eight-bit microcontroller, though the use of other more powerful microcontrollers is contemplated as processors become more powerful and less expensive.

The microcontroller 250, which receives timing signals from crystal 260, decodes the information in the signal and transmits it to a bus interface 270 which interprets the decoded information in accordance with the particular driver information console in the vehicle. Different vehicle manufacturers may use different proprietary designs for their consoles, so the bus interface likewise would be proprietary to the manufacturer. As the interface is a separately-

available component, it need not be described in detail here. Normally, however, the interface will be comprised of an integrated circuit and perhaps four or five external passive, low-cost components.

As supplied by the automobile manufacturer, the driver information console 700 itself, an example of which is shown in Figure 7, may be comprised of a plurality of lamps, light emitting diodes (LEDs), or alternatively may be a liquid crystal display.

The receiver 200 also includes a wheel-rotation recalibration switch interface, associated with microcontroller 250. As has been mentioned, recalibration of the system is necessary in order to "teach" the system any new wheel locations resulting from rotation of the tires. In fact, the same structure may be used at manufacture to "teach" the system the initial wheel location (e.g. left front and rear, right front and rear, for a four-wheeled vehicle) at the time of manufacture.

Also shown at the upper left hand corner of receiver 200 in Figure 1 is power conditioning circuitry 280, which includes a voltage regulator for reducing and adjusting the standard voltage (e.g. 13.8 volts) provided by a vehicle electrical system to a stable 5.0 volts used by the circuitry in the radio frequency, microcontroller, and driver information console interface circuitry.

In accordance with another feature of the invention, each receiver system is able to "learn" the codes associated with its respective transmitters. This feature contributes further to the anti-clash capabilities described earlier. Each receiver is "taught" the necessary codes at the time of manufacture. Referring to Figure 7, driver information console 700 has two subminiature buttons 710 and 720, located near tire pressure warning display lamps 730-760. In the preferred embodiment, the two buttons are depressed simultaneously for three seconds, to place the system in "learn" mode for approximately 60 seconds. During this time, the receiver will be sensitive to receipt of a distinctive learn mode signal from one of its tire-mounted transmitters. In order to send the learn mode signal, a strong magnet is swept over the outside of each of the vehicle

tires near each respective transmitter. As each transmitter receives the resulting magnetic signal, it transmits its learn signal back to the system receiver, which has been synthesized to learn its new family of transmitter codes.

The sequence in which the transmitters teach the receiver (i.e. the order in which the magnet is passed by each of the vehicle wheels) determines the current location of each tire on the vehicle, e.g. left front, left rear, right front, right rear, etc. This process enables easy start-up position calibration when the system is installed at the factory where the vehicle is assembled.

Another function of passage of the magnet across the transmitters is to "wake up" the transmitters from a sleep mode into which they are placed at the time of manufacture, in order to reduce significant battery drain prior to installation, and thus extend transmitter shelf life.

The receiver also may be made sensitive to additional transmitter codes, such as a common replacement code, in order to effect replacement of a transmitter in the event of damage.

The "learn" feature is important not only at the time of manufacture, but also during routine maintenance of the vehicle, for example, when the tires are rotated. Since the receiver 200 is programmed to associate the codes of its transmitters with the locations of those transmitters on the vehicle (e.g. left front, left rear, right front, right rear), when the tires are rotated, the locations must be relearned; otherwise, in the event of excessive decrease of tire pressure in a particular tire, the display on the driver information console would provide incorrect information.

As shown in Figure 7, the two sub-miniature buttons 710 and 720 are labeled "former" and "present", respectively. Immediately after tire rotation, a service technician presses the "former" button 710 repeatedly until the desired tire location is illuminated on the driver information console 700. After the former position has been indexed in this manner, the technician presses the "present" button 720 until the present position of the tire is illuminated on console 700. After the "present" button is released, the former and present

positions of any one tire will flash sequentially, followed by a pause (which may be, for example, one half-second long) to indicate the recalibration to be stored. This information could also be displayed on an LCD display. This new tire location will be recalibrates into the system receiver when both the former and the present buttons are pressed together for a brief period, less than three seconds. This procedure is repeated for each of the tires in the system, and concludes when the last tire has been recalibrated by depressing both former and present buttons together for ten seconds, for example.

As an example, in a standard tire rotation, the front tires are shifted to the back, and the back tires will be shifted to the front. A first recalibration step would be to press the "former" button 710 until the left front light on the driver information console 700 is illuminated. Then, "present" button 720 would be pressed until the left rear light on the console 700 is illuminated. When both former and present buttons are depressed, the location of the transmitter, shifted from left front to left rear, will be stored in receiver 200.

While the invention has been described in detail with reference to a preferred embodiment, various changes and modifications within the scope and spirit of the invention will be apparent to those of working skill in this technological field. Thus, the invention is to be considered as limited only by the scope of the appended claims.

What is claimed is:

1. In a vehicle having a plurality of wheels, each of said wheels having a corresponding plurality of tires mounted thereon, a tire pressure monitoring system including a display interface inside said vehicle for providing an indication of abnormal tire pressure, said system further comprising, for each of said tires, sensing/transmitting means which comprise:

means for sensing pressure;

means for producing signals indicative of temperature-compensated pressure of a respective one of said tires;

means for encoding said signals so as to provide encoded signals, identifying said each of said tires, and location thereof on said vehicle uniquely; and

means for transmitting said encoded signals;

said system further comprising:

means for receiving said encoded signals;

means for decoding said encoded signals, and providing display signals accordingly;

means for providing a display indicative of low pressure and location of said each of said tires in accordance with said display signals; and

means for recalibrating said system such that, in the event of rotation of tires on said vehicle, said system reacquires information on said location of each of said tires.

2. A system as claimed in claim 1, wherein said means for sensing pressure comprises:

a transducer having a housing with an open end closed off by a diaphragm to define a chamber, the chamber being filled with dry nitrogen, a side of the diaphragm not facing said dry nitrogen being exposed to an interior of said tire; and

a normally closed switch comprising first and second contacts, said second contacts being associated with said diaphragm, wherein said diaphragm moves away from said first contacts to open said normally closed switch when a pressure of one of said tires falls below a predetermined value.

3. A system as claimed in claim 1, wherein said means for producing signals comprises a surface acoustic wave (SAW) device.

4. A system as claimed in claim 3, wherein said means for receiving said encoded signals comprises a regenerative receiver and a SAW frequency control device.

5. A system as claimed in claim 1, wherein said means for decoding said encoded signals comprises a microcontroller.

6. A system as claimed in claim 5, wherein said means for recalibrating said system comprises said microcontroller and pushbuttons associated with said means for providing a display, wherein depression of said pushbuttons in a predetermined manner programs said microcontroller to store location of said tires on said vehicle.

7. A system as claimed in claim 1, wherein said means for encoding comprises an application specific integrated circuit (ASIC), and said encoded signals comprise a multiple-bit identification code, a one-bit pressure code, and a one bit learn code.

8. A system as claimed in claim 7, wherein said ASIC comprises means for providing a dwell time between outputted encoded signals, said dwell time being predetermined in accordance with said multiple-bit identification code.

9. A system as claimed in claim 1, further comprising a plurality of battery means for powering a respective one of said sensing/transmitting means.

10. A system as claimed in claim 6, wherein said means for providing a display comprises a driver information console and said pushbuttons, said drive information console also providing additional information concerning operation of said vehicle.

11. A system as claimed in claim 6, wherein said multiple-bit identification code is a 12-bit code.

12. A system as claimed in claim 6, wherein said multiple-bit identification code is a 20-bit code.

13. A system as claimed in claim 6, wherein said multiple-bit identification code is a 24-bit code.

AMENDED CLAIMS

[received by the International Bureau on 30 August 1994 (30.08.94); original claims 1-13 replaced by amended claims 1-19 (4 pages)]

1. In a vehicle having a plurality of wheels, each of said wheels having at least one tire mounted thereon, a tire pressure monitoring system including a display interface inside said vehicle for providing an indication of abnormal tire pressure, said system further comprising, for each of said tires, sensing/transmitting means which comprise:

means for sensing pressure;

means for producing signals indicative of temperature-compensated pressure of a respective one of said tires;

means for encoding said signals so as to provide encoded signals, identifying said each of said tires, and location thereof on said vehicle uniquely; and

means for transmitting said encoded signals;

said system further comprising:

means for receiving said encoded signals;

means for decoding said encoded signals, and providing display signals accordingly; and

means for providing a display indicative of low pressure and location of said each of said tires in accordance with said display signals;

characterized in that the sensing/transmitting means are mounted internally of the tire, and in that the system comprises means for recalibrating said system such that, in the event of rotation of tires on said vehicle, said system reacquires information on said location of each of said tires.

2. A system as claimed in claim 1, wherein said means for recalibrating said system comprises a microcontroller and pushbuttons associated with said means for providing a display, wherein depression of said pushbuttons in a predetermined manner programs said microcontroller to store location of said tires on said vehicle.

3. A system as claimed in claim 2, wherein said means tor recalibrating said system further comprises a magnetically-activated switch, activated in response to presence of a magnetic field in a vicinity thereof, and wherein activation of said switch in conjunction with said depression of said push buttons in said predetermined manner programs said microcontroller to store location of said tires on said vehicle.

4. A system as claimed in claim 2, wherein said means for providing a display comprises a driver information console and said pushbuttons, said driver information console also providing additional information concerning operation of said vehicle.

5. A system as claimed in claim 1, wherein said means for encoding comprises an application specific integrated circuit (ASIC), and said encoded signals comprise a multiple-bit identification code.

6. A system as claimed in claim 5, wherein said multiple-bit identification code is a 12-bit code.

7. A system as claimed in claim 5, wherein said multiple-bit identification code is a 20-bit code.

8. A system as claimed in claim 5, wherein said multiple-bit identification code is a 24-bit code.

9. A system as claimed in claim 1, wherein said means for encoding comprises an application specific integrated circuit (ASIC), and said encoded signals comprise a one-bit pressure code indicating a state of tire pressure.

10. A system as claimed in claim 1, wherein said means for encoding comprises an application specific integrated circuit (ASIC), and said encoded signals comprise a one-bit learn code indicative of whether said sens-

ing/transmitting means is providing information to teach said means for recalibrating so as to enable said system to reacquire information on said location of each of said tires.

11. A system as claimed in claim 1, wherein said means for encoding comprises an application specific integrated circuit (ASIC), said ASIC in turn comprising means for providing a dwell time between outputted encoded signals, said encoded signals comprising a multiple-bit identification code, and said dwell time being predetermined in accordance with said multiple-bit identification code.

12. A system as claimed in claim 11, wherein said multiple-bit identification code is a 12-bit code.

13. A system as claimed in claim 11, wherein said multiple-bit identification code is a 20-bit code.

14. A system as claimed in claim 11, wherein said multiple-bit identification code is a 24-bit code.

15. A system as claimed in claim 1, wherein said means for sensing pressure comprises:

a transducer having a housing with an open end closed off by a diaphragm to define a chamber, the chamber being filled with dry nitrogen, a side of the diaphragm not facing said dry nitrogen being exposed to an interior of said tire; and

a normally closed switch comprising first and second contacts, said second contacts being associated with said diaphragm, wherein said diaphragm moves away from said first contacts to open said normally closed switch when a pressure of one of said tires falls below a predetermined value.

16. A system as claimed in claim 1, wherein said means for producing signals comprises a surface acoustic wave (SAW) device.

17. A system as claimed in claim 16, wherein said means for receiving said encoded signals comprises a regenerative receiver and a SAW frequency control device.

18. A system as claimed in claim 1, wherein said means for decoding said encoded signals comprises a microcontroller.

19. A system as claimed in claim 1, further comprising a plurality of battery means for powering a respective one of said sensing/transmitting means.

STATEMENT UNDER ARTICLE 19(1)

Claims 1-19 are pending in the application.

Claim 1 has not been amended.

Claim 7 has been divided into what are now claims 5 and 9.

Claims 3, 10, 11, and 12-14 are newly added.

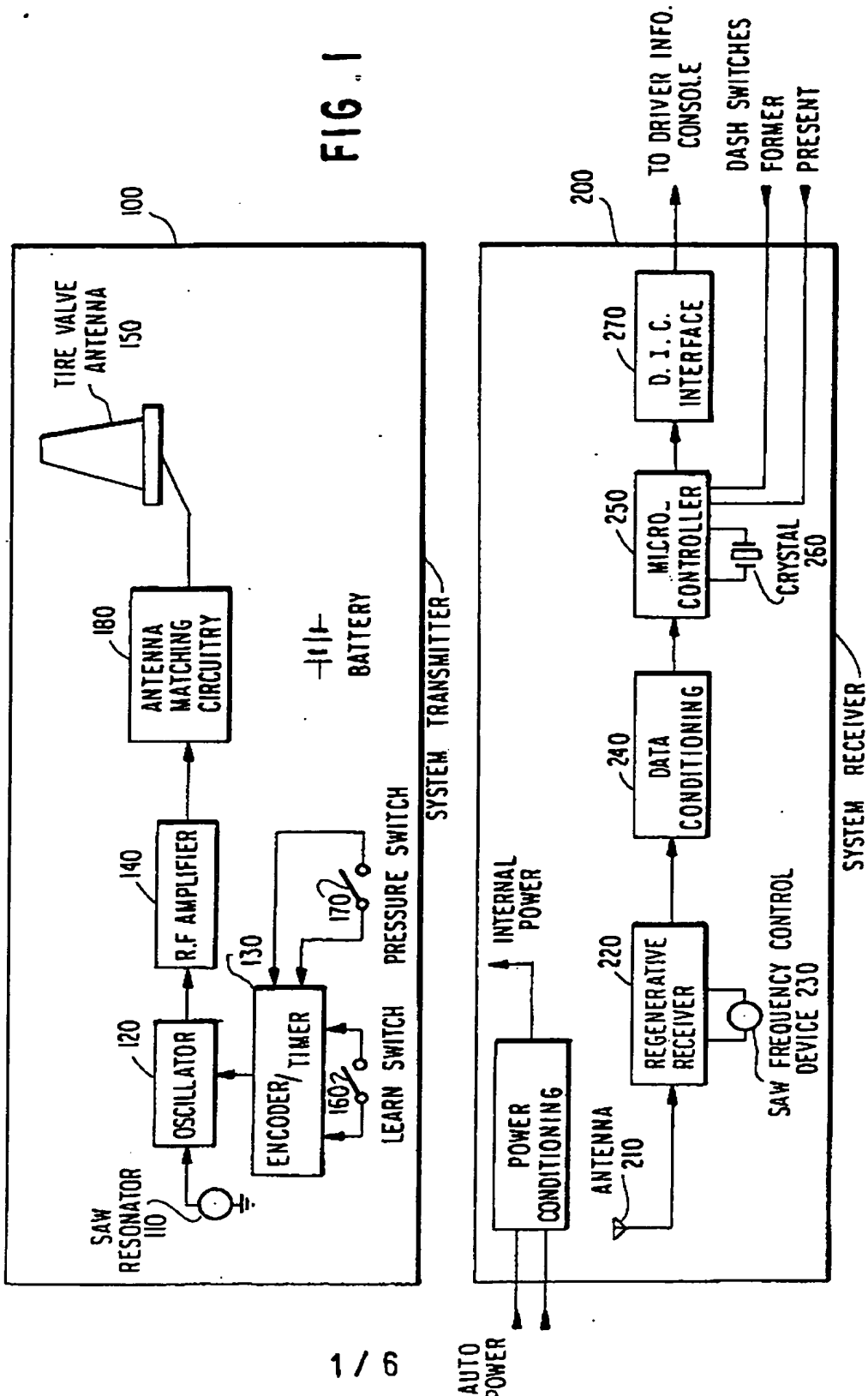
Original claim 8 has been cancelled.

The remaining claims have been renumbered as follows:

Claim 2 corresponds to original claim 6; claim 4 corresponds to original claim 10; claims 6-8 correspond to original claims 11-13; and claims 15, 16, 17, 18 and 19 correspond to original claims 2, 3, 4, 5, and 9, respectively.

It is submitted that the claims are proper in form and present patentable subject matter over the art of record as well as any other known art.

FIG. 1



SUBSTITUTE SHEET

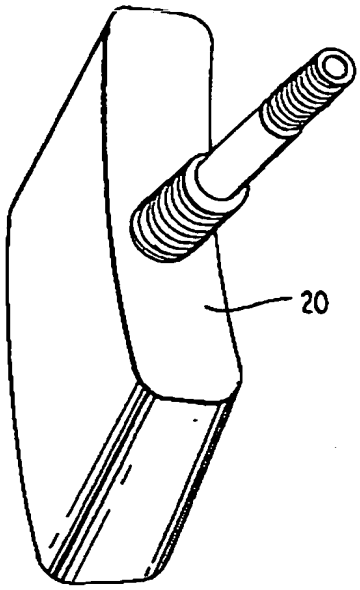


FIG. 2

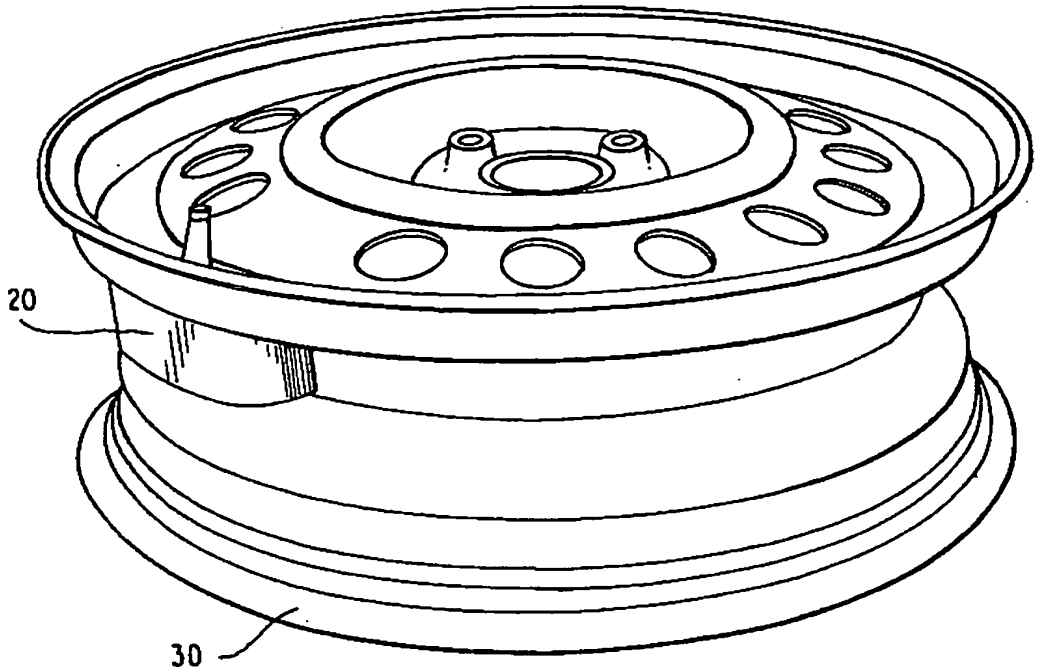


FIG. 3

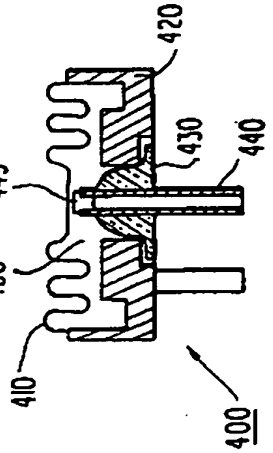


FIG.4

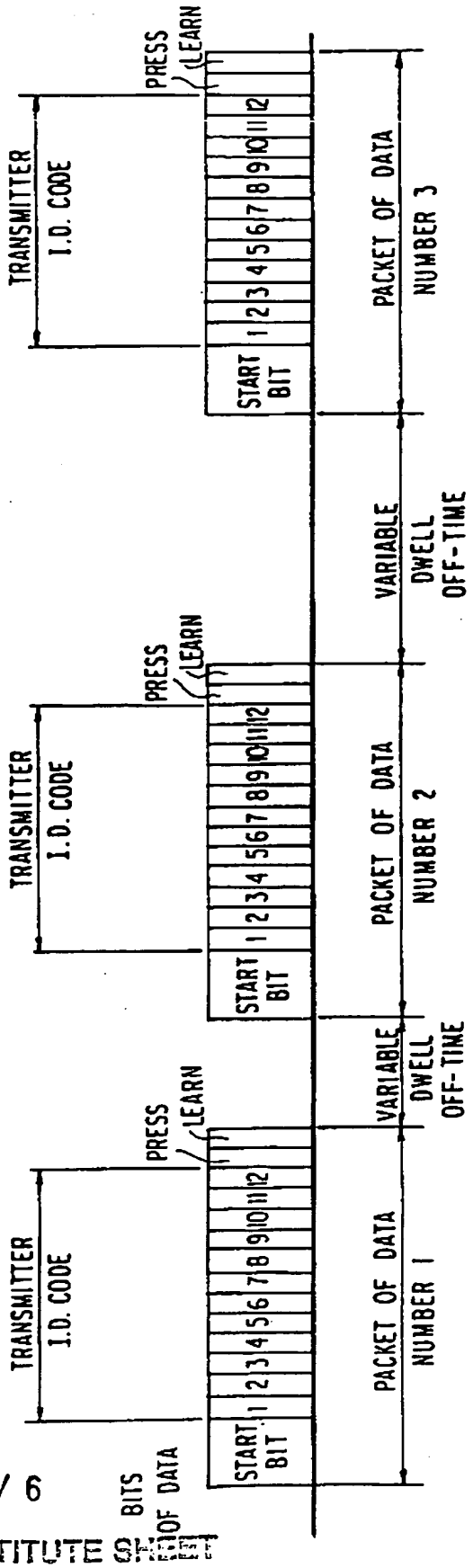


FIG.5

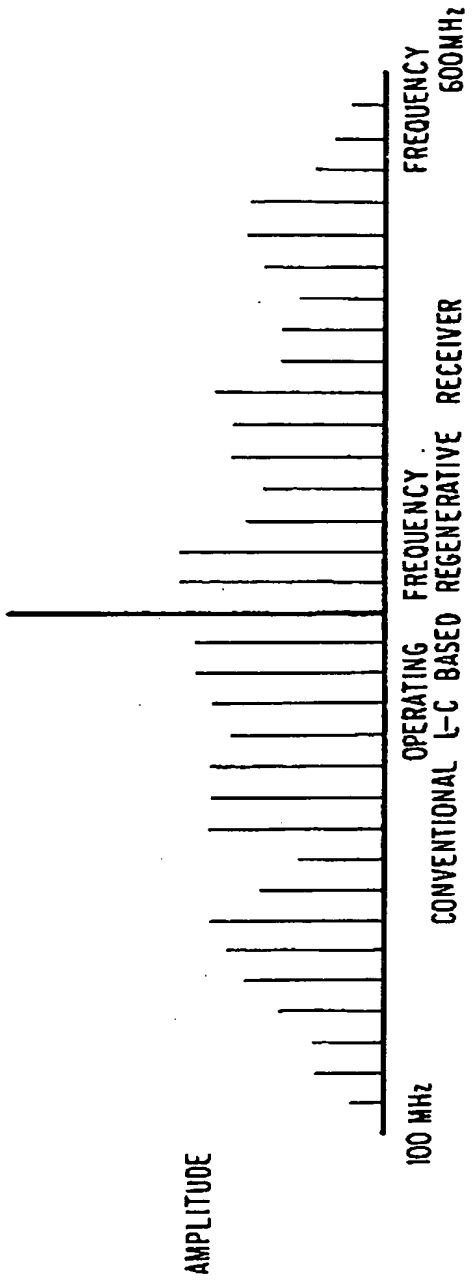


FIG.6A
PRIOR ART

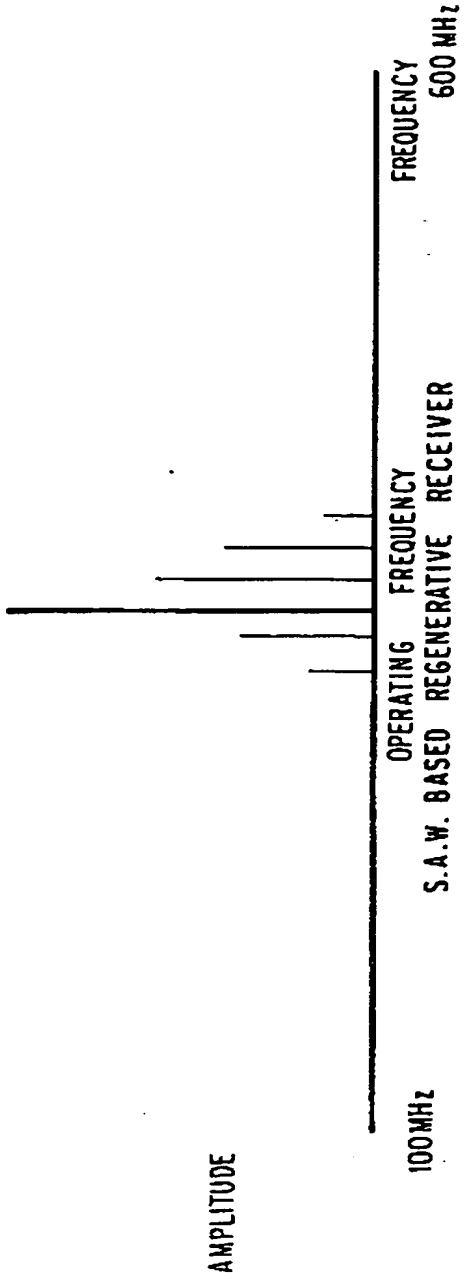
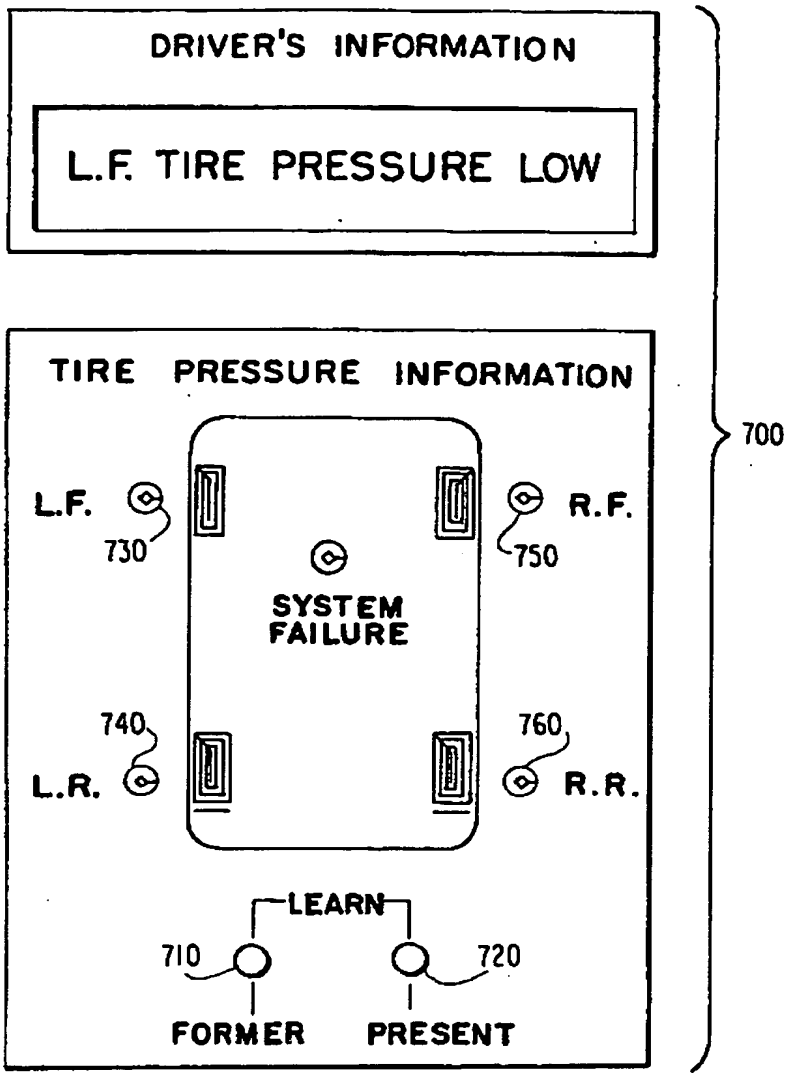


FIG.6B

FIG.7



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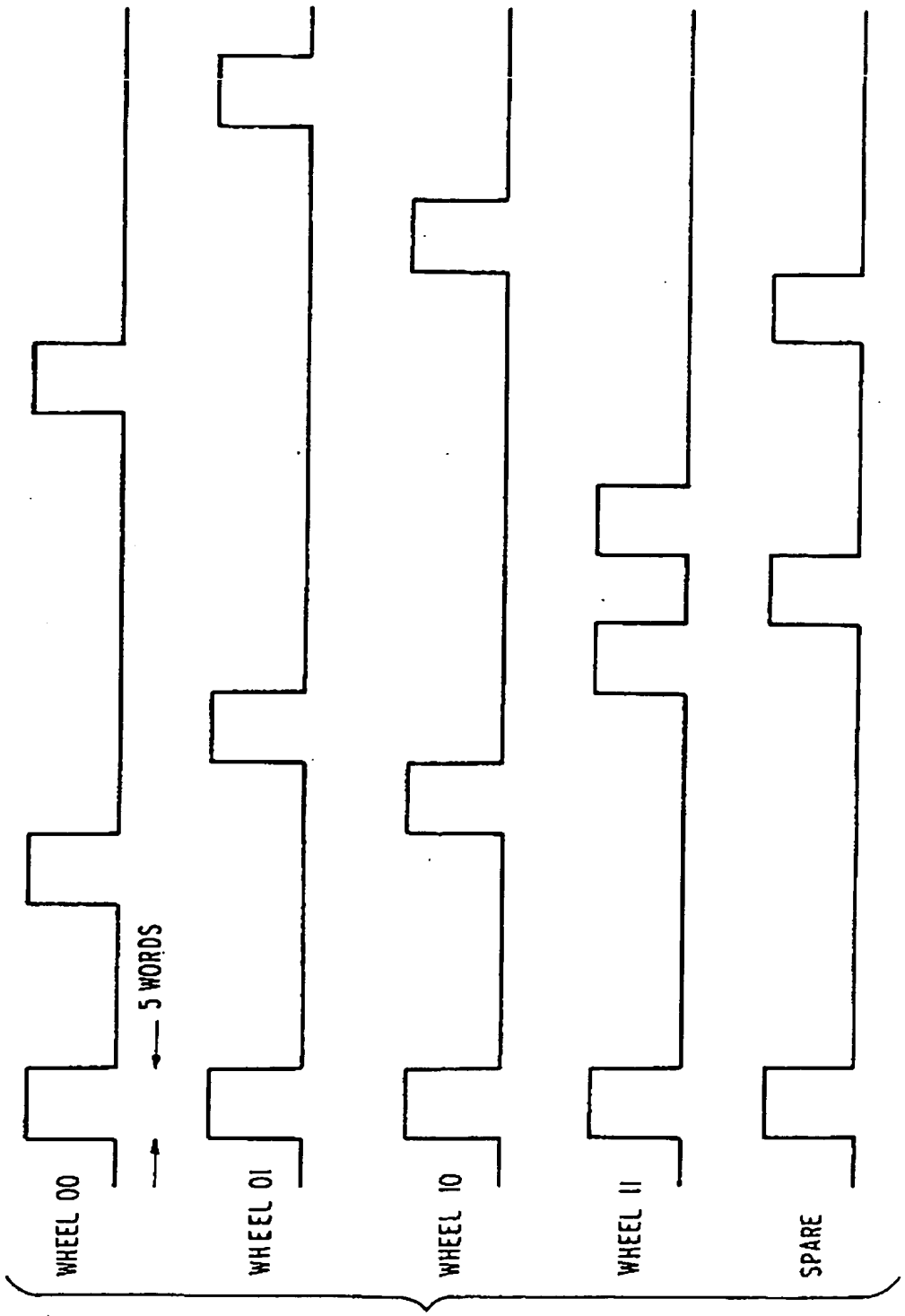

FIG. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US93/01995

A. CLASSIFICATION OF SUBJECT MATTER
IPC(5) :B60C 23/00
US CL :340/447
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 340/438,442,445

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US, A, 4,734,674 (THOMAS ET AL.) 29 March 1988, See figures 1,2,8a,8b.	1,5-6,8,9,10 2-4,7,11-13
Y	US, A, 5,109,213 (WILLIAMS) 28 April 1992, See figures 1 and 8-11.	1-13
Y	US, A, 4,319,220 (PAPPAS ET AL.) 09 March 1982, See figures 2-4.	1-13
Y	US, A, 4,970,491 (SAINT ET AL.) 13 November 1990, See figures 1 and 4.	1-13
A	US, A, 4,694,273 (FRANCHINO) 15 September 1987, See figures 3 and 4.	1-13

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be part of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search
07 MAY 1993

Date of mailing of the international search report
21 JUN 1993

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